puris

26 Jan. 2017

Edward S. Andrews
West Virginia Department of Environmental Protection
Division of Air Quality
601 57th Street, SE
Charleston, WV 25304

Mr. Andrews:

Based on your helpful comments during the 12 Jan. meeting, Puris has made some revisions to our air emissions calculations. Particularly, estimates for the EIGA unit now consider particulate at PM30 and all oversize particles. Available data on post-product recovery (post-cyclone) particulate PSD have been incorporated and nothing smaller than 100 microns is present. Refinements have been made to the PAM model as well to more closely reflect the actual products melted in the furnace instead of the pure component cases we presented previously. In both of these batch processes, emissions are based on maximum possible operating time in an 8760 hour year.

The total Potential To Emit estimations for the EIGA and PAM processes are 2.35 lb/hr or 8.76 ton/yr. Puris remains confident that our facility does not require an air emissions permit. I've attached revised process narratives and calculations for a formal determination by WVDEP that an air permit is not required for the titanium powder process. We understand the formal determination process may take up to 20 days. Please let us know if you need additional information for your review.

Regards,

Michael Siesky
Vice President of Operations, Puris LLC

www.purisllc.com

78 Northpointe Drive

puris

304.777.4270

Bruceton Mills, WV 26525

WEST VIRGINIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF AIR QUALITY
601 57th Street, SE
Charleston, WV 25304
Phone: (304) 926-0475
www.dep.wv.gov/daq

PERMIT DETERMINATION FORM (PDF)

FOR AGENCY USE ONLY: PLANT I.D. # _____

PDF # _____ PERMIT WRITER: _____

1. NAME OF APPLICANT (AS REGISTERED WITH THE WV SECRETARY OF STATE'S OFFICE):
Puris, LLC

RECEIVED
JAN 30 2017
WV DEP / DIV OF AIR QUALITY

2. NAME OF FACILITY (IF DIFFERENT FROM ABOVE):

3. NORTH AMERICAN INDUSTRY CLASSIFICATION SYSTEM (NAICS) CODE:
331492

4A. MAILING ADDRESS: 78 Northpointe Dr.
Bruceton Mills, WV 26525

4B. PHYSICAL ADDRESS: 78 Northpointe Dr.
Bruceton Mills, WV 26525

5A. DIRECTIONS TO FACILITY (PLEASE PROVIDE **MAP** AS **ATTACHMENT A**):

5B. NEAREST ROAD:	5C. NEAREST CITY OR TOWN:	5D. COUNTY:
Northpointe Dr.	Hazelton	Preston
5E. UTM NORTHING (KM):	**5F. UTM EASTING (KM):**	**5G. UTM ZONE:**
4391047.00	626706.63	17S

6A. INDIVIDUAL TO CONTACT IF MORE INFORMATION IS REQUIRED:	6B. TITLE:
Adam Byrd	Sr. Engineer

6C. TELEPHONE:	6D. FAX:	6E. E-MAIL:
(304) 777-4270 x204	(304) 842-1972	abyrd@purisllc.com

7A. DAQ PLANT I.D. NO. (FOR AN EXISTING FACILITY ONLY):
077-00091 (SiC Process)

7B. PLEASE LIST ALL CURRENT 45CSR13, 45CSR14, 45CSR19 AND/OR TITLE V (45CSR30) PERMIT NUMBERS ASSOCIATED WITH **THIS** PROCESS (FOR AN EXISTING FACILITY ONLY):
-

7C. IS THIS PDF BEING SUBMITTED AS THE RESULT OF AN ENFORCEMENT ACTION? IF YES, PLEASE LIST: **NO**

8A. TYPE OF EMISSION SOURCE (CHECK ONE):
☒ **NEW SOURCE** ☐ **ADMINISTRATIVE UPDATE**
☐ **MODIFICATION** ☐ **OTHER** (PLEASE EXPLAIN IN 11B)

8B. IF ADMINISTRATIVE UPDATE, DOES DAQ HAVE THE APPLICANT'S CONSENT TO UPDATE THE EXISTING PERMIT WITH THE INFORMATION CONTAINED HEREIN?
☐ **YES** ☐ **NO**

9. IS *DEMOLITION* OR PHYSICAL *RENOVATION* AT AN EXISTING FACILITY INVOLVED? ☐ **YES** ☒ **NO**

10A. DATE OF ANTICIPATED INSTALLATION OR CHANGE:	10B. DATE OF ANTICIPATED START-UP:
June/2012 (as FMW Composite Systems)	July/2012 (as FMW Composite Systems)

11A. PLEASE PROVIDE A **DETAILED PROCESS FLOW DIAGRAM** SHOWING EACH PROPOSED OR MODIFIED PROCESS EMISSION POINT AS **ATTACHMENT B**.

11B. PLEASE PROVIDE A **DETAILED PROCESS DESCRIPTION** AS **ATTACHMENT C**.

12. PLEASE PROVIDE **MATERIAL SAFETY DATA SHEETS (MSDS)** FOR ALL MATERIALS PROCESSED, USED OR PRODUCED AS **ATTACHMENT D**. FOR CHEMICAL PROCESSE, PLEASE PROVIDE A MSDS FOR EACH COMPOUND EMITTED TO AIR.

13A. **REGULATED AIR POLLUTANT EMISSIONS:**

⇒ **FOR A NEW FACILITY,** PLEASE PROVIDE PLANT WIDE EMISSIONS BASED ON THE POTENTIAL TO EMIT (PTE) FOR THE FOLLOWING AIR POLLUTANTS INCLUDING ALL PROCESSES.

⇒ **FOR AN EXISTING FACILITY,** PLEASE PROVIDE THE PROPOSED CHANGE IN EMISSIONS BASED ON THE PTE OF ALL PROCESS CHANGES FOR THE FOLLOWING AIR POLLUTANTS.

PTE FOR A GIVEN POLLUTANT IS TYPICALLY BEFORE AIR POLLUTION CONTROL DEVICES AND IS COLLECTED BASED ON THE MAXIMUM DESIGN CAPACITY OF PROCESS EQUIPMENT.

POLLUTANT	**HOURLY PTE** (LB/HR)	**YEARLY PTE** (TON/YR) (HOURLY PTE MULTIPLIED BY 8760 HR/YR) DIVIDED BY 2000 LB/TON
PM	2.35	8.76
PM_{10}	0.49	0.91
VOCs	-	-
CO	-	-
NO_x	-	-
SO_2	-	-
Pb	-	-
HAPs (AGGREGATE AMOUNT)	-	-
TAPs (INDIVIDUALLY)*	-	-
OTHER (INDIVIDUALLY)*	-	-

* ATTACH ADDITIONAL PAGES AS NEEDED

13B. PLEASE PROVIDE ALL **SUPPORTING CALCULATIONS** AS **ATTACHMENT E.**

CALCULATE AN HOURLY AND YEARLY PTE OF EACH PROCESS EMISSION POINT (SHOWN IN YOUR DETAILED PROCESS FLOW DIAGRAM) FOR ALL AIR POLLUTANTS LISTED ABOVE INCLUDING INDIVIDUAL HAP'S (LISTED IN SECTION 112[b] OF THE 1990 CAAA), TAP'S (LISTED IN 45CSR27), AND OTHER AIR POLLUTANTS (E.G. POLLUTANTS LISTED IN TABLE 45-13A OF 45CSR13, MINERAL ACIDS PER 45CSR7, ETC.).

14. **CERTIFICATION OF DATA**

I, MICHAEL SIESKY (*TYPE NAME*) ATTEST THAT ALL THE REPRESENTATIONS CONTAINED IN THIS APPLICATION, OR APPENDED HERETO, ARE TRUE, ACCURATE, AND COMPLETE TO THE BEST OF MY KNOWLEDGE BASED ON INFORMATION AND BELIEF AFTER REASONABLE INQUIRY, AND THAT I AM A ***RESPONSIBLE OFFICIAL**** (*PRESIDENT, VICE PRESIDENT, SECRETARY OR TREASURER, GENERAL PARTNER OR SOLE PROPRIETOR*) OF THE APPLICANT.

SIGNATURE OF RESPONSIBLE OFFICIAL: Michael Siesky

TITLE: VP of Operations DATE: 1 / 27 / 2017.

** THE DEFINITION OF THE PHRASE '***RESPONSIBLE OFFICIAL***' CAN BE FOUND AT 45CSR13, SECTION 2.23.

NOTE: PLEASE CHECK ENCLOSED ATTACHMENTS:

☐ **ATTACHMENT A** ☐ **ATTACHMENT B** ☐ **ATTACHMENT C** ☐ **ATTACHMENT D** ☐ **ATTACHMENT E**

RECORDS ON ALL CHANGES ARE REQUIRED TO BE KEPT AND MAINTAINED ON-SITE FOR TWO (2) YEARS.

THE PERMIT DETERMINATION FORM WITH THE INSTRUCTIONS CAN BE FOUND ON DAQ'S PERMITTING SECTION WEB SITE:

www.dep.wv.gov/daq

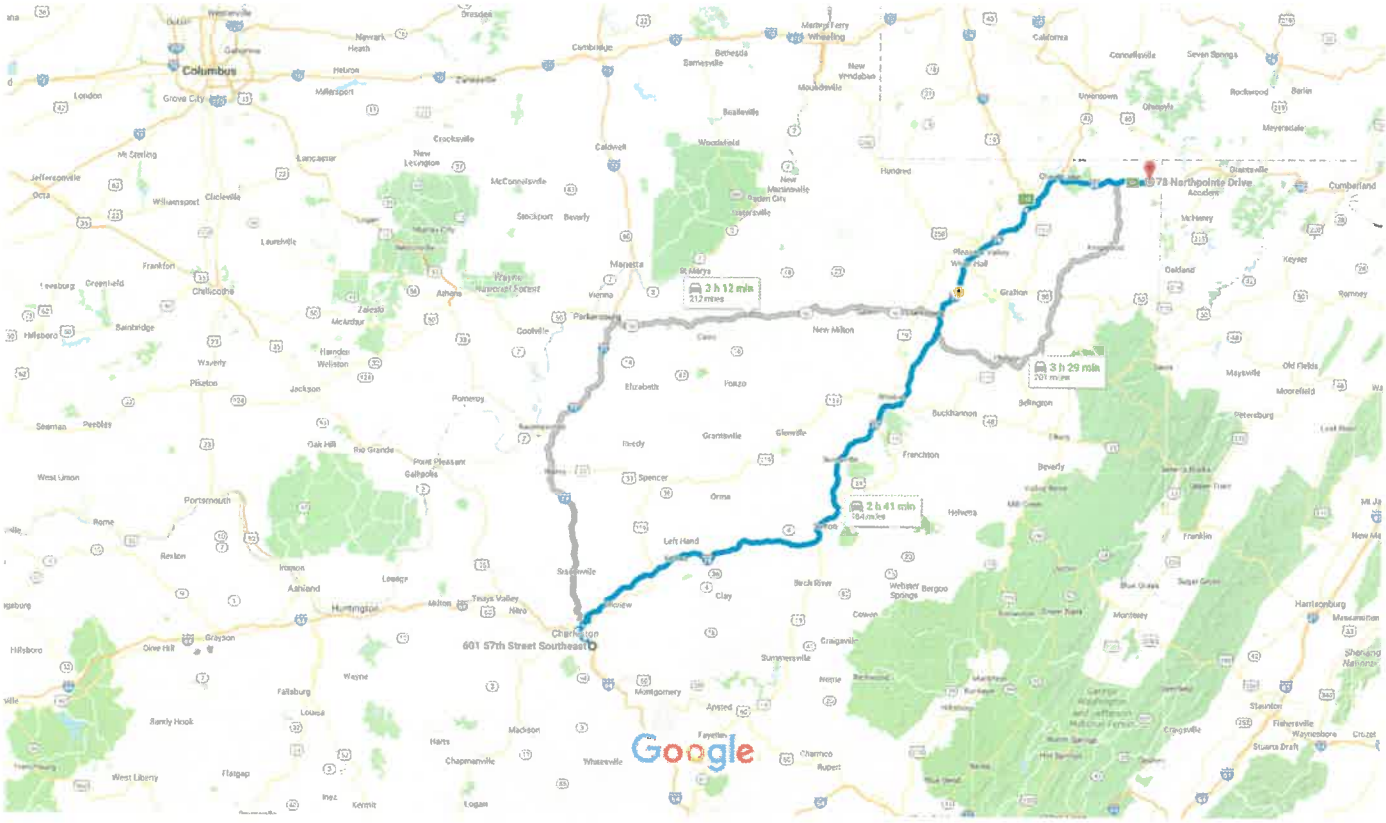
ATTACHMENT A

Directions from WV DEP to Puris, LLC

Google Maps

601 57th St SE, Charleston, WV 25304 to 78 Northpointe Dr, Bruceton Mills, WV 26525

Drive 184 miles, 2 h 41 min



Map data ©2017 Google 10 mi

601 57th St SE

Charleston, WV 25304

Get on I-64 W/I-77 N from MacCorkle Ave SE

7 min (2.5 mi)

1. Head northeast on 57th St SE toward Washington Ave SE — 0.1 mi
2. Turn left onto MacCorkle Ave SE — 1.8 mi
3. Turn right onto 36th St SE — 0.2 mi
4. Continue onto 36th St Southeast Bridge — 0.2 mi
5. Use the right lane to take the ramp onto I-64 W/I-77 N — 0.1 mi

Follow I-79 N and I-68 E to Hazelton Gladesville Rd in Second. Take exit 29 from I-68 E

2 h 36 min (181 mi)

6. Merge onto I-64 W/I-77 N

2.5 mi

7. Use the right 2 lanes to take the Interstate 77 N/Interstate 79 N exit toward Parkersburg

0.5 mi

8. Continue onto I-77 N

1.4 mi

9. Keep right at the fork to continue on I-79 N, follow signs for Clarksburg

148 mi

10. Use the right 2 lanes to take exit 148 for I-68 E toward Cumberland

0.3 mi

11. Continue onto I-68 E

28.2 mi

12. Take exit 29 for County Rd 5 toward Hazelton Rd

0.3 mi

Take Casteel Rd to your destination

2 min (0.7 mi)

13. Turn left onto Hazelton Gladesville Rd

0.2 mi

14. Turn right onto Casteel Rd

0.5 mi

15. Turn left

Destination will be on the right

387 ft

78 Northpointe Dr

Bruceton Mills, WV 26525

These directions are for planning purposes only. You may find that construction projects, traffic, weather, or other events may cause conditions to differ from the map results, and you should plan your route accordingly. You must obey all signs or notices regarding your route.

ATTACHMENT B

Process Flow Diagrams for EIGA and PAM

Customer Supply

Venting & Purging (Pressure of melt chamber)
DN 12 tube 15x1,5
DN 25
Ar-02-25/16
0,5...1,0 MPa 2,5...3,5 Nm³/min (Standard)

0,4 MPa (4bar)
Y225R
V215M
PI 294
B

0...10 MPa
PI 289
V289M
V287M
set point 2,0 MPa
PSAL 201 =B3+S1-S855
0...10 MPa
PI 283
V283M
X285P
Pruefanschluss test connection

6,8 MPa (68bar)
TIS
TIC 225 =E03+S1-E990
=E03+S1-E990 40 kW
TSAH
V281M lockable
PI
2,5...4,0 MPa 20...25 Nm³/min (Standard)
Argon

GS 021-022 =F1+S1-S1013
=F1+S1-Y1012
V021P
F020
GS 211-212 =F2+S1-S1113/S1115
=F2+S1-Y1112
V211P
Atomization Gas max.5 MPa (50 bar)

PSAL 200 =B3+S1-S857
DN 12 tube 15x1,5
Ar-02-19/5

M801 =01+S1+M1301
M802 =L01+S1-M1401
GC 802 =L01+S1-M1401
GS 803 =L1+S1-S1433
GS 804 =L1+S1-S1435
Chamber door locked
GS 801 =F7+S1-B1957

GS 023-024 =F1+S1-S1034
V023P =F1+S1-Y1032
air
GS 017-018 =F1+S1-S1024
V017P =F1+S1-Y1022
air
=F1+S1-Y1072
V019P
MSAH 801 =B5+S1-B892
GS 027-028 =F1+S1-S1043
V027P =F1+S1-Y1042
PI 020
=F1+S1-Y1052/Y1054
GS 025-026 =F1+S1-S1056/1058
V025P

Venting
V213P =F2+S1-Y1122
GS 213-214 =F2+S1-S1124
Atomization (Pressure of melt chamber)
V217P =F2+S1-Y1104
GS 217-218 =F2+S1-S1106
V215M
V219M

PS 002 =B1+S1-B802
PI 011
FI 207 =B1+S1-B822
VM231 DN 19 Tube 22x1,5

GS 003-004 =F1+S1-B1003
=F1+S1-Y1002
A
Y093R
Y094R
PI 010
+0,3 bar
DN100
V003P
F001

GS 101-102 =F1+S1-S1064
=F1+S1-Y1062
air
V101P
V103M

PIS 004 =B1+S1-B811
DN100
DN25
PI 040
F040
V047M
V043M
V045M

GS 005-006 =E1+S1-B965/966
V005P =E1+S1-Y962
P002 WP0500 =E2+S1-M971
P001 NC0200 =F1+S1-M951
2 1

V081P =B4+S1-Y882
DN200
DN150
=F7+S11-A1384
GS 041-042 =F3+S1-B1153
=F3+S1-Y1152
V041P
FOF0
FI
V156M
V153P
=F7+S11-Y1887
FDI 251 =F7+S11-P1376
FDI 250 =F7+S11-P1371
V151P =F7+S11-Y1886
R3/4"
hose connection 6/4
cleaning filter cartridges

O2-Analyser
-0,3 bar
QISA 802 =B4+S1-B871
FI
A
Argon
Pressure min/max: 5/ 10 bar
Flow-rate: 1200 NL/ min (for 10 sec.)

consumers
PSAL 091 =F7+S1-S1827
6 bar
Compressed Air or Nitrogen
Pressure min/max: 6/10 bar
Flow-rate: 5 l/s

Interfaces
1 2 1 = ALD supply
2 = customer supply

Micro	Index	Anzahl	Feld	Art der Änderung Kind of changes	Datum	Name
Bewertungsgruppe Schweißnähte allgemein ISO 5817-C; Druckbehälter ISO 5817-B nach AD-2000-Merkblatt HP 5/1					leerlerte Hefte sind zu grabulieren	
Allgemeintoleranzen ISO 2768-mK; Schweißen DIN ISO 13920-BF; Gewinde ISO 965-2; Mauerwerk N072-03						

ALD Vacuum Technologies GmbH
Wilhelm-Rohn-Str. 35
D-63450 Hanau
Tel.: +49-6181-307-0
Fax: +49-6181-307-3290

Maßstab / Scale 1:1

Oberflächen ISO 1302
Vakuum-Dichtflächen N076-11

Benennung Description
R&I-Schema EIGA 50/1000
P&I-Diagram EIGA 50/1000

Mit der Entgegennahme dieser Zeichnung verpflichtet sich der Empfänger, Sie vertraulich zu behandeln. Er darf sie nur zur Ausführung des ihm erteilten Auftrages benutzen, nie besonders also nicht ohne vorherige schriftliche Zustimmung vervielfältigen, Dritten zugänglich machen oder in anderer Weise verwerten. Bei Zuwiderhandlungen haftet uns der Empfänger für alle Schäden.

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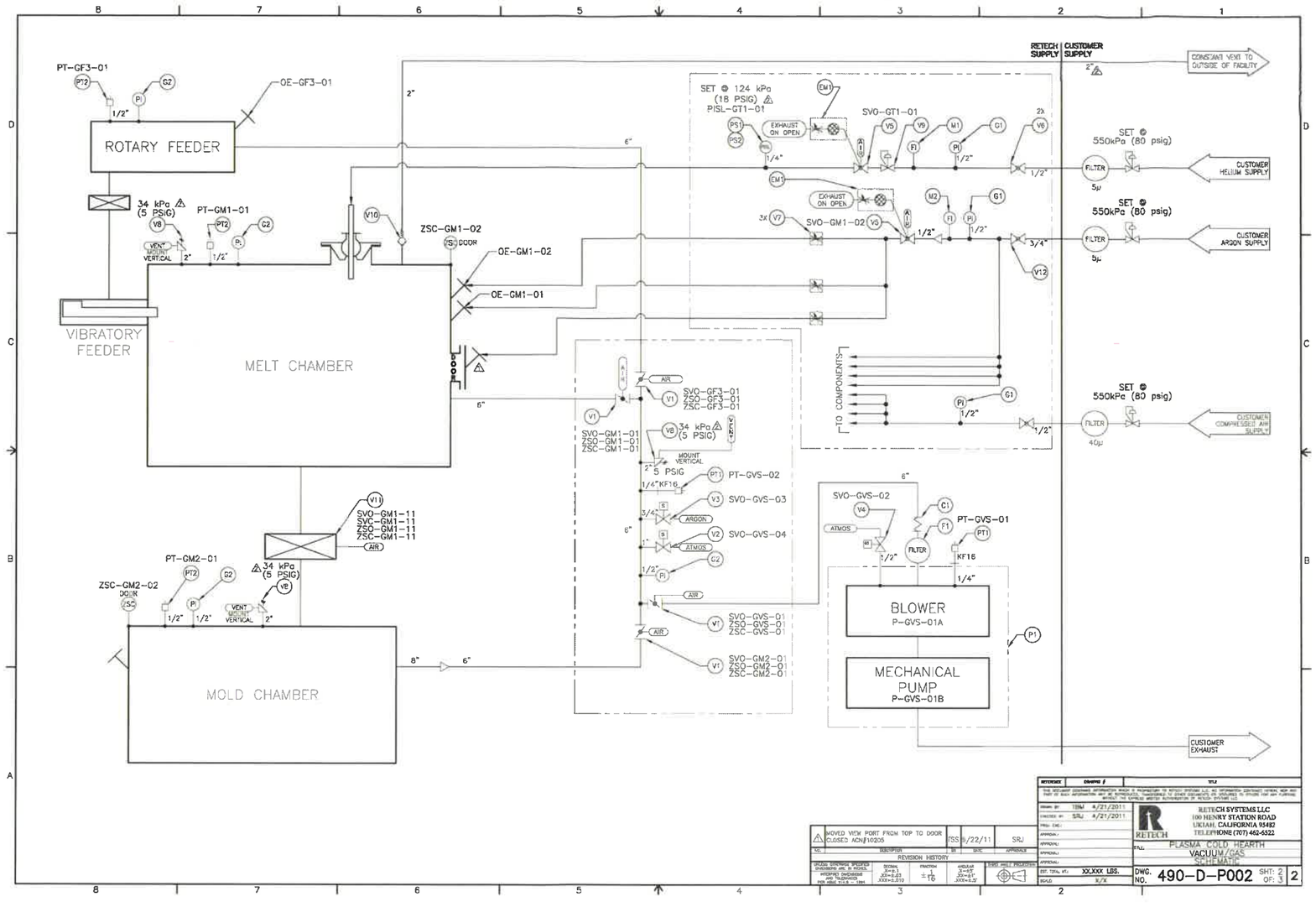
Alle nicht bemaßten Kanten nach ISO 13715: +0,3 +0,1 -0,1 -0,3

	Datum	Name
Gez.	10.12.2010	Hölderbach
Gepr.	02.08.2011	Zuckerst.
Norm.		

Micro: 1.420-073072 | Index | Blatt Sheet 1 von of 1

Entstanden aus:

CIM-Datenbase - 2.8.2011 10:48:09


RETECH SUPPLY
CUSTOMER SUPPLY
CONSTANT VENT TO OUTSIDE OF FACILITY
PT-GF3-01
OE-GF3-01
ROTARY FEEDER
VIBRATORY FEEDER
MELT CHAMBER
MOLD CHAMBER
SET @ 124 kPa (18 PSIG)
PISL-GT1-01
SVO-GT1-01
SET @ 550kPa (80 psig)
CUSTOMER HELIUM SUPPLY
CUSTOMER ARGON SUPPLY
CUSTOMER COMPRESSED AIR SUPPLY
TO COMPONENTS
34 kPa (5 PSIG)
PT-GM1-01
ZSC-GM1-02
OE-GM1-02
OE-GM1-01
SVO-GF3-01
ZSO-GF3-01
ZSC-GF3-01
SVO-GM1-01
ZSO-GM1-01
ZSC-GM1-01
5 PSIG
PT-GVS-02
SVO-GVS-03
SVO-GVS-04
SVO-GVS-01
ZSO-GVS-01
ZSC-GVS-01
SVO-GM1-11
SVC-GM1-11
ZSO-GM1-11
ZSC-GM1-11
PT-GM2-01
ZSC-GM2-02
SVO-GM2-01
ZSO-GM2-01
ZSC-GM2-01
SVO-GVS-02
PT-GVS-01
BLOWER
P-GVS-01A
MECHANICAL PUMP
P-GVS-01B
CUSTOMER EXHAUST
MOVED VIEW PORT FROM TOP TO DOOR CLOSED ACN#10205
REVISION HISTORY
RETECH SYSTEMS LLC
100 HENRY STATION ROAD
UKIAH, CALIFORNIA 95482
TELEPHONE (707) 462-6522
PLASMA COLD HEARTH
VACUUM/GAS
SCHEMATIC
DWG. NO. 490-D-P002
SHT: 2 OF: 3
2

ATTACHMENT C

Process Descriptions for EIGA and PAM

Process Narrative – EIGA
Prepared by Adam Byrd, 7 Dec 2016
Revised by Adam Byrd 25 Jan 2017

Puris produces titanium powder via the Electrode Induction Gas Atomization (EIGA) method. An electrode of approximately 70 mm dia x 1000 mm length is manually loaded into the furnace then automatically lowered into a water-cooled induction coil fed by a high voltage high frequency power supply. The electrode couples with the electric field and the tip is heated to the melting point of the metal and drips off. The molten metal falls through a nozzle, where it is impinged upon by high pressure argon which atomizes the metal. The small molten metal drops quickly cool and solidify as they fall through the atomization tower. Product recovery is attained via a cyclone. Gas is then passed through two HEPA filters classified as H13 under DIN EN 1822-7/A. Powdered metal recovered by the cyclone is collected in a sealed container and further processed under inert atmosphere in closed systems. Powder that makes it past the cyclone is stopped by the filter, collected, and disposed as scrap.

The atomizer is able to run in an open or closed configuration. Historically, it has run in the open configuration with argon supplied from a tank farm outside. After passing through the HEPA filtration system, gas was vented to atmosphere. In late 2016 Puris installed and commissioned an argon recycling system, where filtered atomization gas is captured, compressed, and reused. Makeup gas is still supplied by the tank farm as required. In this configuration, there are no emissions under normal operation. At the time of writing, the effectiveness of the argon recycling system is being evaluated. The atomizer retains the ability to run from the tank farm if required but it is anticipated to use recycled argon whenever possible for economic reasons. A Piping and Instrumentation Diagram for the atomizer in open configuration is given in Appendix A.

Emissions calculations are based upon AP-42 methodology, however Puris' titanium atomization operations are not adequately described by any of the categories of Table B.2-1. Detailed particle size analyses of Puris powder are known from sieve analysis [ASTM B214] and light scattering [ASTM B822].

A particle size distribution of powder collected post-cyclone is shown in Figure 2. This curve was obtained from the average several runs during argon recycling commissioning. The powder collected post-cyclone is fairly coarse compared to the desired product collected in the atomization can. The high-efficiency cyclone was designed specifically for titanium powder.

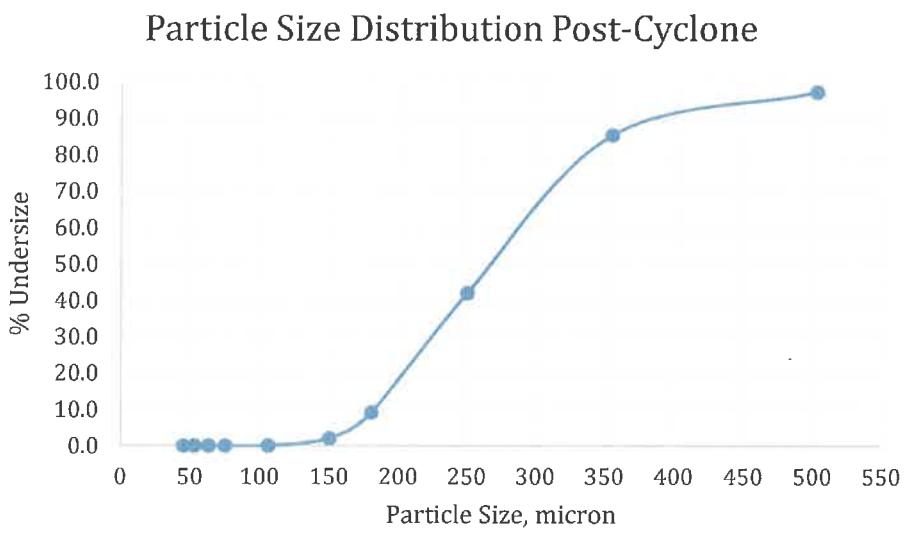


Fig. 2: Particle Size Distribution of Post-Cyclone Powder

Potential to emit can then be calculated on the basis of all material that passes the cyclone. Results are given in Table 1. It is known that approximately 3.5% of powder atomized makes it past the cyclone. The rate of atomization can be calculated from the linear feed rate of 28 mm/min for a 70 mm x 990 mm electrode. Atomization is a batch process, interrupted by the need to change electrodes and periodically clean. An average bar turnaround time of 9.4 min/electrode is used, and a cleaning schedule of 4 hour once per week is used.

It can be seen that potential to emit fine particles is independent of throughput. Product recovery of fine powders is so efficient that there are no particles small enough for consideration, even with an upper limit of 30 μm instead of 10 μm as suggested by Edward Andrews of WV Department of Environmental Protection's Division of Air Quality. For a complete treatment of the question, however, the case of all post-cyclone material escaping is considered.

Table 1: EIGA Emission Estimates for Uncontrolled and Controlled Process

Size Range (micron)	<2.5	2.5-6	6-10	10-30	>30
Collection Eff (%) (HEPA filter @ 0.3 μm)	99.9	99.9	99.9	99.9	99.9
Generic distribution (%), cum. % < given size	0	0	0	0	100
Mass in size range before control (ton/yr)	0	0	0	0	7.8
Mass in size range before control (lb/hr)	0	0	0	0	1.8
Mass in size range after control (ton/yr)	0	0	0	0	0.01
Mass in size range after control (lb/hr)	0	0	0	0	0.002
Cumulative Mass before Control (ton/yr)	0	0	0	0	**7.8**
Cumulative Mass before Control (lb/hr)	**0**	**0**	**0**	0	**1.8**
Cumulative Mass after Control (ton/yr)	0	0	0	0	0.01
Cumulative Mass after control (lb/hr)	0	0	0	0	0.002

The results in Table 1 clearly show that the EIGA unit has no potential to emit PM-30, and the total PTE is under the threshold of 6 lb/hr or 10 ton/yr.

PAM Process Narrative
Prepared by Adam Byrd, 7 Dec 2016
Revised by Adam Byrd, 25 Jan 2017

Puris owns a plasma arc cold-hearth melting furnace (PAM). This furnace performs primary melt of titanium sponge and alloying elements to cast cylindrical titanium alloy electrodes for atomization at Puris. Its operation is batchwise, with feedstock loaded into a feeder, melted in a water-cooled hearth, tilt-poured into molds, and finally cooled and removed from a hold chamber. It typically takes three hours to melt and cast electrodes, three hours to cool them, and an additional hour to remove the castings and swap molds before resuming melting. The furnace has seen infrequent use since its installation; a review of its operating log showed that the plasma torch has a total time of 325 operating hours since its commissioning in July 2012 to December 2016. Melting operations are carried out in an inert atmosphere at a pressure slightly above atmospheric pressure. This design provides an increased margin of safety over vacuum melting technologies and minimizes the vaporization of metals, particularly aluminum. Melting is accomplished by a helium plasma arc. Viewports are cooled by argon. Helium from the torch and cooling argon are continuously vented to atmosphere as a mixed stream after being cooled by a U-type double pipe heat exchanger. The positive pressure in the furnace is maintained by a weighted relief valve in the vent line. No further filtration is installed on the exhaust line. A schematic showing vacuum lines and gas supply is shown in Appendix A.

AP 42 5th ed. Volume 1 Chapter 12: Metallurgical Industry does not contain any subsections that describe the operation of this furnace nor the materials it processes. No particle size distribution data specific to the process exhaust is available. A particle size distribution is assumed from AP 42 5th ed., Compilation of Air Pollutant Emission Factors, Vol.1: Stationary Point and Area Sources, Appendix B2.2, Category 8: Melting, Smelting, Refining, Metals, except Aluminum. This PSD is reproduced in Table 1. As no control device is installed on the furnace exhaust, 100% of the calculated generation rate is reported as potential to emit.

Table 1: Particle Size Distribution for Melting, Smelting, and Refining Metals, Except Aluminum

Particle Size, µm	Cumulative % < Stated Size (Uncontrolled)
2.5	82
6.0	89
10.0	92

Vaporized metal can condense as metal particles inside the furnace. Much of this material accumulates on the interior surfaces of the furnace and is normally collected as a metal oxides during periodic cleanouts. The potential to emit, however, is calculated with the assumption that any metal vaporized is entrained in the exhaust gases. Vapor-liquid equilibrium data for multiple metal systems are not available in published literature. Similarly, vapor pressure data is available only for single metals under vacuum conditions. As such, vapor composition is assumed to follow Raoult's Law and Dalton's Law. Vapor pressure of the individual components is taken to be the pure component vapor pressure times the mole fraction of the component in the liquid phase, and the total vapor pressure as the sum of the individual vapor pressures.

Vapor pressure is calculated at 1660°C, the upper end of the melting point range for Ti-6Al-4V. This alloy has been produced with the greatest frequency in the PAM. Vapor pressure of the liquid metals are assumed to take the form of Antoine's equation. Antoine equation coefficients are taken from published literature; temperatures or pressures in the regime of interest sometimes exceed the given validity range, but these extrapolations are the best approximations available [1-4].

Only a few degrees of superheat is possible in the PAM, as the water-cooled hearth quickly cools molten metals to below the melting point when not being heated. Since the vapor pressure of solids is much less than that of liquids, it is appropriate to only consider the time the torch is running when calculating emissions.

Exhaust gas flowrates are known to be 13 SCFM helium 60 SCFM argon. Assuming that the system follows Dalton's Law, the mole fraction of a given metal in the exhaust gas and the total mass flowrate of metal in exhaust gases can be calculated.

As previously stated, Puris primarily processes titanium alloys. Using the method outlined above and PSD data from AP 42, emissions for several titanium alloy products are given in Table 2. To provide a single worst case scenario for potential to emit, emissions for a titanium aluminide product are given. Titanium aluminides have a large aluminum content, which has the highest vapor pressure of all metals melted at Puris.

Table 2: Worst Case Scenario Potential to Emit from PAM

Size, μm	<2.5	<6.0	<10.0	Total
Cumulative Percent at Less Than Stated Size	82	89	92	100
Cumulative Uncontrolled Particulate Generation at Less Than Stated Size (lb/hr)	0.35	0.43	0.49	0.53
Cumulative Uncontrolled Particulate Generation at Less Than Stated Size (ton/yr)	0.81	0.88	0.91	0.99

The generation rate of particulate is less than the permitting threshold value of 6 lb/hr or 10 tons/yr in the considered worst case scenario. As previously mentioned, most vaporized metals condense on the furnace walls, so the emissions of Table 2 provide a grossly overestimated upper end for particulate emissions by the PAM.

References:

1	Cr	http://webbook.nist.gov/cgi/cbook.cgi?Name=chromium&Units=SI&cTP=on
2	Mo	https://www.nist.gov/sites/default/files/documents/srd/jpcrd313.pdf
3	B	http://www.physics.nyu.edu/kentlab/How_to/ChemicalInfo/VaporPressure/morepressure.pdf
4	All others	Alcock, CB. Canadian Metallurgical Quarterly, 23, 309, 1984.

ATTACHMENT D

Safety Data Sheets

Ti-6Al-4V Powder

SAFETY DATA SHEET

Section 1. Identification

Product identifier used on the label: Ti-6Al-4V Powder
Other means of identification: Ti-6Al-4V Powder
Product type: Solid
Recommended use and restrictions
Identified uses: Not available.
Supplier's details :

Puris, LLC.
78 Northpointe Dr.
Bruceton Mills, WV 26525
Phone: 304-777-4270
Fax: 304-842-1972

Emergency telephone number (with hours of operation): 304-777-4270 M-F 8AM-5PM

Section 2. Hazards identification

Classification of the substance or mixture: Not classified as flammable solid to CFR Title 49 Vol. 2 Appendix E
Ingredients of unknown toxicity: Not applicable
Ingredients of unknown ecotoxicity: Not applicable

GHS label elements
Hazard pictograms :
Signal word :
Hazard statements : Further sieving of product could result in classification as flammable solid.
Precautionary statements
General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking.
Response : Not applicable.
Storage : Not applicable.
Disposal : Not applicable.
Other hazards which do not result in classification: Not available.

Section 3. Composition/information on ingredients

Substance/mixture: Mixture
Other means of identification : Ti-6Al-4V, Grade 5 Titanium, Grade 23 Titanium
CAS number/other identifiers
CAS number : Not applicable
EC number : Mixture.
Product code : Not available.

Ti-6Al-4V Powder

Element	Percentage (wt%)	CAS Number
Titanium	90	7440-32-6
Aluminum	6	7429-90-5
Vanadium	4	7440-62-2

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Eye contact
Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 20 minutes. Get medical attention if irritation occurs.

Inhalation
Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact
Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion
Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects
Inhalation : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.

Eye contact : No known significant effects or critical hazards.
Over-exposure signs/symptoms
Skin contact No specific data.
Ingestion No specific data
Inhalation No specific data
Eye contact : No specific data.

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary
Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments : No specific treatment.
Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. Itmay be dangerous to the person providing aid to give mouth-to-mouth resuscitation.
See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media
Suitable extinguishing media: Use a Type D fire extinguisher for metal fires.
Unsuitable extinguishing media: Do not use water or foam. Do not use CO_2.
Specific hazards arising from the chemical: Flammable solid.
Hazardous thermal decomposition products: Decomposition products may include the following materials: metal oxide/oxides
Special protective actions for fire-fighters: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk.
Special protective equipment for fire-fighters: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
For non-emergency personnel:
No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders
If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill: Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber
brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Do not ingest. Avoid contact with eyes, skin and clothing. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use only non-sparking tools.
Empty containers retain product residue and can be hazardous. Do not reuse container.

Conditions for safe storage, including any incompatibilities

Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well ventilated area, away from incompatible materials (see section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters - Occupational exposure limits

Ingredient name	Exposure Limits
Aluminum	**NIOSH REL (United States)**
	TWA: 5 mg/m³ 10 hour(s). Form: Respirable fraction
	TWA: 10 mg/m³ 10 hour(s). Form: Total
	OSHA PEL (United States)
	TWA: 5 mg/m³, (as Al) 8 hour(s). Form: Respirable fraction

	TWA: 15 mg/m³, (as Al) 8 hour(s). Form: Total dust
	ACGIH TLV (United States)
	TWA: 1 mg/m³ 8 hour(s). Form: Respirable fraction
Vanadium	**NIOSH REL (United States)**
	TWA: 0.05 mg/m³
	OSHA PEL (United States)
	TWA: 0.5 mg/m³
	ACGIH TLV TWA (United States)
	TLV: 0.05 mg/m³

Recommended monitoringprocedures
If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Appropriate engineering controls
Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls: Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures
Hygiene measures
Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.
Eye/face protection Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts.

Skin protection
Hand protection
Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Body protection Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection
Use a properly fitted, air-purifying or supplied air respirator complying with an

approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance
Physical state Solid. [Gray spherical powder]
Color Gray.
Odor Odorless.
Odor threshold Not available.
pH: Not available.
Melting point/freezing point: 1600°C (2912°F)
Boiling point/boiling range : 3200°C (5792°F)
Flash point Not available.
Evaporation rate Not available.
Flammability (solid, gas) : Not available.
Lower and upper explosive (flammable) limits: Not available.
Vapor pressure: Not available.
Relative density: 4.5
Vapor density: Not available.
Solubility: Insoluble in the following materials: cold water and hot water.
Partition coefficient: n-octanol/water Not available.
Auto-ignition temperature Not available.
Viscosity Not available.
SADT : Not available.
Decomposition temperature : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.
Chemical stability The product is stable.
Possibility of hazardous reactions: Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid Heat, flames, ignition sources and incompatibles.
Incompatible materials : Mineral acids, Molten alkali salt, Liquid oxygen, Oxides of Cu, Fe, Bi and some others. Carbon dioxide (CO_2).
Hazardous decomposition products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects
Acute toxicity
There is no data available.
Irritation/Corrosion
Skin : Not available.
Eyes : Not available.
Respiratory : Not available.
SensitizationThere is no data available.

Ti-6Al-4V Powder

Carcinogenicity There is no data available.

	ACGIH	IARC	EPA	NIOSH	NTP	OSHA
Aluminum	A4	-	-	-	-	-
Vanadium	A4	2B	-	-	-	-

Mutagenicity There is no data available.
Teratogenicity There is no data available.
Reproductive toxicity There is no data available.
Specific target organ toxicity (single exposure) There is no data available
Specific target organ toxicity (repeated exposure): There is no data available.
Aspiration hazard There is no data available.
Information on the likely routes of exposure: Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects
Eye contact : No known significant effects or critical hazards.
Inhalation : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics
Eye contact : No specific data.
Inhalation No specific data.
Skin contact: No specific data.
Ingestion: No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure
Potential immediate effects: Not available.
Potential delayed effects : Not available.

Long term exposure
Potential immediate effects: Not available.
Potential delayed effects: Not available.

Potential chronic health effects
General : No known significant effects or critical hazards.
Carcinogenicity : No known significant effects or critical hazards.
Mutagenicity : No known significant effects or critical hazards.
Teratogenicity : No known significant effects or critical hazards.
Developmental effects : No known significant effects or critical hazards.
Fertility effects : No known significant effects or critical hazards.
There is no data available.

Numerical measures of toxicity
Acute toxicity estimates: There is no data available.

Section 12. Ecological information

Toxicity

Ti-6Al-4V Powder

There is no data available.

Persistence and degradability

There is no data available.

Bioaccumulative potential There is no data available.

Mobility in soil

Soil/water partition coefficient (K_{OC}): Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods

The generation of waste should be avoided or minimized wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT	IMDG	IATA
UN number	NA	NA	NA
UN proper shipping name	NA	NA	NA
Transport Hazard Class(es)	NA	NA	NA
Packing Group	NA	NA	NA
Environmental Hazards	NO	NA	NO
Special Precautions for User	NA	NA	NA
Additional Information	-	-	-

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: Not available

Section 15. Regulatory information

Safety, health and environmental regulations specific for the product:
No known specific national and/or regional regulations applicable to this product (including its ingredients).

U.S. Federal regulations

TSCA 8(a) IUR Exempt/Partial exemption: Not determined
United States inventory (TSCA 8b): All components are listed or exempted.
SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Titanium; Aluminum; Vanadium
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Titanium: Fire hazard, Delayed (chronic) health hazard; Aluminum: Fire hazard, reactive
Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs): Not listed
Clean Air Act Section 602 Class I Substances : Not listed
Clean Air Act Section 602 Class II Substances : Not listed
DEA List I Chemicals (Precursor Chemicals) : Not listed
DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 313

	Product Name	CAS Number	Concentration (wt%)
Form R - Reporting Requirements	Aluminum Vanadium	7429-90-5 7440-47-3	6 4
Supplier Notification	Aluminum Vanadium	7429-90-5 7440-47-3	6 4

SARA 313 notifications must not be detached from the MSDS and any copying and redistribution of the MSDS shall include copying and redistribution of the notice attached to copies of the MSDS subsequently redistributed.

State regulations

Massachusetts The following components are listed: Aluminum
New York : None of the components are listed.
New Jersey : The following components are listed: Titanium; Aluminum
Pennsylvania : The following components are listed: Aluminum;
California Prop. 65: No products were found.

Section 16. Other information

History

Date of issue mm/dd/yyyy: 07/24/2014

Version: 1

Prepared by : Puris, LLC

Key to abbreviations :

ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

CP Ti Powder

SAFETY DATA SHEET

Section 1. Identification

Product identifier used on the label: CP Ti Powder
Other means of identification: Ti Powder
Product type: Solid
Recommended use and restrictions
Identified uses: Not available.
Supplier's details :

Puris, LLC
78 Northpointe Dr.
Bruceton Mills, WV 26525
Phone: 304-777-4270
Fax: 304-842-1972

Emergency telephone number (with hours of operation): 304-777-4270 M-F 8AM-5PM

Section 2. Hazards identification

Classification of the substance or mixture: : Not classified as flammable solid to CFR Title 49 Vol. 2 Appendix E
Ingredients of unknown toxicity: Not applicable
Ingredients of unknown ecotoxicity: Not applicable

GHS label elements
Hazard pictograms :
Signal word : Danger
Hazard statements : Further sieving of product could result in classification as flammable solid.
Precautionary statements
General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking.
Response : Not applicable.
Storage : Not applicable.
Disposal : Not applicable.
Other hazards which do not result in classification: Not available.

Section 3. Composition/information on ingredients

Substance/mixture: Mixture
Other means of identification : Titanium Powder
CAS number/other identifiers
CAS number : Not applicable
EC number : Mixture.
Product code : Not available.

CP Ti Powder

Element	Percentage (wt%)	CAS Number
Titanium	>99%	7440-32-6

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Eye contact
Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 20 minutes. Get medical attention if irritation occurs.

Inhalation
Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact
Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion
Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects
Inhalation : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Eye contact : No known significant effects or critical hazards.

Over-exposure signs/symptoms
Skin contact No specific data.
Ingestion No specific data

CP Ti Powder

Inhalation No specific data
Eye contact : No specific data.

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary
Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments : No specific treatment.
Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. Itmay be dangerous to the person providing aid to give mouth-to-mouth resuscitation.
See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media
Suitable extinguishing media: Use a Type D fire extinguisher for metal fires.
Unsuitable extinguishing media: Do not use water or foam. Do not use CO_2.
Specific hazards arising from the chemical: Flammable solid.
Hazardous thermal decomposition products: Decomposition products may include the following materials: metal oxide/oxides
Special protective actions for fire-fighters: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk.
Special protective equipment for fire-fighters: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
For non-emergency personnel:
No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders
If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up
Small spill: Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber
brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to

accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Do not ingest. Avoid contact with eyes, skin and clothing. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use only non-sparking tools.
Empty containers retain product residue and can be hazardous. Do not reuse container.

Conditions for safe storage, including any incompatibilities

Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well ventilated area, away from incompatible materials (see section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters - Occupational exposure limits

Ingredient name	Exposure Limits
Titanium (as Titanium Dioxide)	TWA: 5 mg/m³ 10 hour(s). Form: Respirable fraction
	TWA: 10 mg/m³ 10 hour(s). Form: Total
	OSHA PEL (United States)
	TWA: 15 mg/m³
	ACGIH TLV (United States)
	TWA: 10 mg/m³ 8 hour(s). Form: Respirable fraction

Recommended monitoring procedures

If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Appropriate engineering controls

Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls: Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures

Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts.

Skin protection

Hand protection

Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.

Body protection Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection
Use a properly fitted, air-purifying or supplied air respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance
Physical state Solid. [Gray spherical powder]
Color Gray.
Odor Odorless.
Odor threshold Not available.
pH: Not available.
Melting point/freezing point: ~1660°C (3020°F)
Boiling point/boiling range : <3000°C (5792°F)
Flash point Not available.
Evaporation rate Not available.
Flammability (solid, gas) : Not available.
Lower and upper explosive (flammable) limits: Not available.
Vapor pressure: Not available.
Relative density: 4.5
Vapor density: Not available.
Solubility: Insoluble in the following materials: cold water and hot water.
Partition coefficient: n-octanol/water Not available.
Auto-ignition temperature Not available.
Viscosity Not available.
SADT : Not available.
Decomposition temperature : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.
Chemical stability The product is stable.
Possibility of hazardous reactions: Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid Heat, flames, ignition sources and incompatibles.
Incompatible materials : Mineral acids, Molten alkali salt, Liquid oxygen, Oxides of Cu, Fe, Bi and some others. Carbon dioxide (CO_2).
Hazardous decomposition products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

CP Ti Powder

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity
There is no data available.

Irritation/Corrosion
Skin : Not available.
Eyes : Not available.
Respiratory : Not available.
SensitizationThere is no data available.

Carcinogenicity There is no data available.

Mutagenicity There is no data available.
Teratogenicity There is no data available.
Reproductive toxicity There is no data available.
Specific target organ toxicity (single exposure) There is no data available
Specific target organ toxicity (repeated exposure): There is no data available.
Aspiration hazard There is no data available.
Information on the likely routes of exposure: Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects
Eye contact : No known significant effects or critical hazards.
Inhalation : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics
Eye contact : No specific data.
Inhalation No specific data.
Skin contact: No specific data.
Ingestion: No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure
Potential immediate effects: Not available.
Potential delayed effects : Not available.

Long term exposure
Potential immediate effects: Not available.
Potential delayed effects: Not available.

Potential chronic health effects
General : No known significant effects or critical hazards.
Carcinogenicity : No known significant effects or critical hazards.
Mutagenicity : No known significant effects or critical hazards.
Teratogenicity : No known significant effects or critical hazards.
Developmental effects : No known significant effects or critical hazards.
Fertility effects : No known significant effects or critical hazards.
There is no data available.

Numerical measures of toxicity
Acute toxicity estimates: There is no data available.

Section 12. Ecological information

Toxicity
There is no data available.
Persistence and degradability
There is no data available.
Bioaccumulative potential There is no data available.
Mobility in soil
Soil/water partition coefficient (K_{OC}): Not available.
Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods
The generation of waste should be avoided or minimized wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT	IMDG	IATA
UN number	NA	NA	NA
UN proper shipping name	NA	NA	NA
Transport Hazard Class(es)	NA	NA	NA
Packing Group	NA	NA	NA
Environmental Hazards	NO	NO	NO
Special Precautions for User	NA	NA	NA
Additional Information	-	-	-

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: Not available

Section 15. Regulatory information

Safety, health and environmental regulations specific for the product:
No known specific national and/or regional regulations applicable to this product (including its ingredients).

U.S. Federal regulations

TSCA 8(a) IUR Exempt/Partial exemption: Not determined
United States inventory (TSCA 8b): All components are listed or exempted.
SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Titanium; Aluminum; Vanadium
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Titanium: Fire hazard, Delayed (chronic) health hazard; Aluminum: Fire hazard, reactive
Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs): Not listed
Clean Air Act Section 602 Class I Substances : Not listed
Clean Air Act Section 602 Class II Substances : Not listed
DEA List I Chemicals (Precursor Chemicals) : Not listed
DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 313

SARA 313 notifications must not be detached from the MSDS and any copying and redistribution of the MSDS shall include copying and redistribution of the notice attached to copies of the MSDS subsequently redistributed.

State regulations

Massachusetts None of the components are listed
New York : None of the components are listed.
New Jersey : The following components are listed: Titanium;
Pennsylvania : None of the components are listed
California Prop. 65: No products were found.

CP Ti Powder

Section 16. Other information

History

Date of issue mm/dd/yyyy:09/15/2015

Version: 2

Prepared by : Puris, LLC

Key to abbreviations :

ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

SAFETY DATA SHEET

Section 1. Identification

Product identifier used on the label: Ti-5Al-5Mo-5V-3Cr Powder
Other means of identification: Ti-5-5-5-3
Product type: Solid
Recommended use and restrictions
Identified uses: Not available.
Supplier's details :

Puris, LLC
78 Northpointe Dr.
Bruceton Mills, WV 26525
Phone: 304-777-4270
Fax: 304-842-1972

Emergency telephone number (with hours of operation): 304-777-4270 M-F 8AM-5PM

Section 2. Hazards identification

Classification of the substance or mixture: Not applicable
Ingredients of unknown toxicity: Not applicable
Ingredients of unknown ecotoxicity: Not applicable

GHS label elements
Hazard pictograms : NA
Signal word : Danger
Hazard statements : Flammable solid.
Precautionary statements
General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking.
Response : Not applicable.
Storage : Not applicable.
Disposal : Not applicable.
Other hazards which do not result in classification: Not available.

Section 3. Composition/information on ingredients

Substance/mixture: Mixture
Other means of identification :
CAS number/other identifiers
CAS number : Not applicable
EC number : Mixture.
Product code : Not available.

Nominal Composition

Element	Percentage (wt%)	CAS Number
Titanium	82	7440-32-6
Aluminum	5	7429-90-5
Molybdenum	5	7439-98-7
Vanadium	5	7440-62-2
Chromium	3	7440-47-3

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Eye contact

Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 20 minutes. Get medical attention if irritation occurs.

Inhalation

Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact

Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion

Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects
Inhalation : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Eye contact : No known significant effects or critical hazards.
Over-exposure signs/symptoms
Skin contact No specific data.
Ingestion No specific data
Inhalation No specific data
Eye contact : No specific data.

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary
Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments : No specific treatment.
Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. Itmay be dangerous to the person providing aid to give mouth-to-mouth resuscitation.
See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media
Suitable extinguishing media: Use a Type D fire extinguisher for metal fires.
Unsuitable extinguishing media: Do not use water or foam. Do not use CO_2.
Specific hazards arising from the chemical: Flammable solid.
Hazardous thermal decomposition products: Decomposition products may include the following materials: metal oxide/oxides
Special protective actions for fire-fighters: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk.
Special protective equipment for fire-fighters: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
For non-emergency personnel:
No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders
If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill: Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber
brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Do not ingest. Avoid contact with eyes, skin and clothing. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use only non-sparking tools.
Empty containers retain product residue and can be hazardous. Do not reuse container.

Conditions for safe storage, including any incompatibilities

Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well ventilated area, away from incompatible materials (see section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

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Section 8. Exposure controls/personal protection

Control parameters - Occupational exposure limits

Ingredient name	Exposure Limits
Aluminum	**NIOSH REL (United States)**
	TWA: 5 mg/m³ 10 hour(s). Form: Respirable fraction
	TWA: 10 mg/m³ 10 hour(s). Form: Total
	OSHA PEL (United States)
	TWA: 5 mg/m³, (as Al) 8 hour(s). Form: Respirable fraction
	TWA: 15 mg/m³, (as Al) 8 hour(s). Form: Total dust
	ACGIH TLV (United States)
	TWA: 1 mg/m³ 8 hour(s). Form: Respirable fraction
Molybdenum	**NIOSH REL (United States)**
	TWA: 5 mg/m³
	OSHA PEL (United States)
	TWA: 15mg/m³
	ACGIH TLV (United States)
	TLV: 3 mg/m³ (respirable) TLV: 10 mg/m³ (inhalable)
Vanadium	**NIOSH REL (United States)**
	TWA: 0.05 mg/m³
	OSHA PEL (United States)
	TWA: 0.5 mg/m³
	ACGIH TLV (United States)
	TLV: 0.05 mg/m³
Chromium	**NIOSH REL (United States)**
	0.5 mg/m³
	OSHA PEL (United States)
	TWA: 1 mg/m³
	ACGIH TLV (United States)
	TWA: 0.5 mg/m³

Recommended monitoring procedures
If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Appropriate engineering controls
Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls: Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures
Hygiene measures
Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.
Eye/face protection Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts.

Skin protection
Hand protection
Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Body protection Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection
Use a properly fitted, air-purifying or supplied air respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties
Appearance
Physical state Solid. [Gray spherical powder]
Color Gray.

Odor Odorless.
Odor threshold Not available.
pH: Not available.
Melting point/freezing point: 1600°C (2912°F)
Boiling point/boiling range : 3200°C (5792°F)
Flash point Not available.
Evaporation rate Not available.
Flammability (solid, gas) : Not available.
Lower and upper explosive (flammable) limits: Not available.
Vapor pressure: Not available.
Relative density: 4.5
Vapor density: Not available.
Solubility: Insoluble in the following materials: cold water and hot water.
Partition coefficient: n-octanol/water Not available.
Auto-ignition temperature Not available.
Viscosity Not available.
SADT : Not available.
Decomposition temperature : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.
Chemical stability The product is stable.
Possibility of hazardous reactions: Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid Heat, flames, ignition sources and incompatibles.
Incompatible materials : Mineral acids, Molten alkali salt, Liquid oxygen, Oxides of Cu, Fe, Bi and some others. Carbon dioxide (CO_2).
Hazardous decomposition products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects
Acute toxicity
There is no data available.
Irritation/Corrosion
Skin : Not available.
Eyes : Not available.
Respiratory : Not available.
SensitizationThere is no data available.

Carcinogenicity There is no data available.

	ACGIH	IARC	EPA	NIOSH	NTP	OSHA
Aluminum	A4	-	-	-	-	-
Molybdenum	A4	-	-	-	-	-
Vanadium	A4	2B	-	-	-	-
Chromium	A4	3	-	-	-	-

Mutagenicity There is no data available.
Teratogenicity There is no data available.
Reproductive toxicity There is no data available.
Specific target organ toxicity (single exposure) There is no data available
Specific target organ toxicity (repeated exposure): There is no data available.
Aspiration hazard There is no data available.
Information on the likely routes of exposure: Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects
Eye contact : No known significant effects or critical hazards.
Inhalation : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics
Eye contact : No specific data.
Inhalation No specific data.
Skin contact: No specific data.
Ingestion: No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure
Potential immediate effects: Not available.
Potential delayed effects : Not available.

Long term exposure
Potential immediate effects: Not available.
Potential delayed effects: Not available.

Potential chronic health effects
General : No known significant effects or critical hazards.
Carcinogenicity : No known significant effects or critical hazards.
Mutagenicity : No known significant effects or critical hazards.
Teratogenicity : No known significant effects or critical hazards.
Developmental effects : No known significant effects or critical hazards.
Fertility effects : No known significant effects or critical hazards.
There is no data available.

Numerical measures of toxicity
Acute toxicity estimates: There is no data available.

Section 12. Ecological information

Toxicity
There is no data available.
Persistence and degradability
There is no data available.

Bioaccumulative potential There is no data available.
Mobility in soil
Soil/water partition coefficient (K_{OC}): Not available.
Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods
The generation of waste should be avoided or minimized wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT	IMDG	IATA
UN number	NA	NA	NA
UN proper shipping name	NA	NA	NA
Transport Hazard Class(es)	NA	NA	NA
Packing Group	NA	NA	NA
Environmental Hazards	NO	NO	NO
Special Precautions for User	NA	NA	NA
Additional Information	-	-	-

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: Not available

Section 15. Regulatory information

Safety, health and environmental regulations specific for the product:
No known specific national and/or regional regulations applicable to this product (including its ingredients).
U.S. Federal regulations
TSCA 8(a) IUR Exempt/Partial exemption: Not determined
United States inventory (TSCA 8b): All components are listed or exempted.
SARA 302/304/311/312 extremely hazardous substances: No products were found.

SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Titanium; Aluminum;
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Titanium: Fire hazard, Delayed (chronic) health hazard; Aluminum: Fire hazard, reactive
Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs): Not listed
Clean Air Act Section 602 Class I Substances : Not listed
Clean Air Act Section 602 Class II Substances : Not listed
DEA List I Chemicals (Precursor Chemicals) : Not listed
DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 313

	Element	CAS Number	Composition (wt%)
Form R - Reporting Requirements	Titanium	7440-32-6	82
	Aluminum	7429-90-5	5
	Molybdenum	7439-98-7	5
	Vanadium	7440-62-2	5
	Chromium	7440-47-3	3
Supplier Notification	Titanium	7440-32-6	82
	Aluminum	7429-90-5	5
	Molybdenum	7439-98-7	5
	Vanadium	7440-62-2	5
	Chromium	7440-47-3	3

SARA 313 notifications must not be detached from the MSDS and any copying and redistribution of the MSDS shall include copying and redistribution of the notice attached to copies of the MSDS subsequently redistributed.

State regulations

Massachusetts The following components are listed: Aluminum
New York : The following components are listed: Titanium, Molybdenum, Chromium
New Jersey : The following components are listed: Titanium; Aluminum; Vanadium; Molybdenum, Chromium
Pennsylvania : The following components are listed: Aluminum; Vanadium; Chromium, Molybdenum
California Prop. 65: No products were found.

Section 16. Other information

History

Date of issue mm/dd/yyyy: 05/04/2015

Version: 1

Prepared by : Puris, LLC.

Key to abbreviations :

ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Ti-43.67Al-4Nb-0.1B-0.5W-1Cr at% + 200 ppm C Powder

SAFETY DATA SHEET

Section 1. Identification

Product identifier used on the label: Ti-43.67Al-4Nb-0.1B-0.5W-1Cr at% + 200 ppm C Powder
Other means of identification:
Product type: Solid
Recommended use and restrictions
Identified uses: Not available.
Supplier's details :

Puris, LLC
78 Northpointe Dr.
Bruceton Mills, WV 26508
Phone: 304-777-4270
Fax: 304-842-1972

Emergency telephone number (with hours of operation): 304-777-4270 M-F 8AM-5PM

Section 2. Hazards identification

Classification of the substance or mixture: Not classified as flammable solid to CFR Title 49 Vol. 2 Appendix E
Ingredients of unknown toxicity: Not applicable
Ingredients of unknown ecotoxicity: Not applicable

GHS label elements
Hazard pictograms :
Signal word :
Hazard statements :
Precautionary statements
General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Further sieving of powder could result in classification of the powder as a flammable solid.
Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking.
Response : Not applicable.
Storage : Not applicable.
Disposal : Not applicable.
Other hazards which do not result in classification: Not available.

Section 3. Composition/information on ingredients

Substance/mixture: Mixture
Other means of identification : Titanium aluminide
CAS number/other identifiers
CAS number : Not applicable
EC number : Mixture.
Product code : Not available.

Ti-43.67Al-4Nb-0.1B-0.5W-1Cr at% + 200 ppm C Powder

Element	Percentage (wt%)	CAS Number
Titanium	Balance	7440-32-6
Aluminum	29.9-30.9	7429-90-5
Niobium	8.70-9.30	7440-03-1
Chromium	1.20-1.50	7440-47-3
Tungsten	2.00-2.40	7440-33-7
Boron	0.02-0.05	7440-42-8
Iron	<0.10	7439-89-6

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Eye contact

Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 20 minutes. Get medical attention if irritation occurs.

Inhalation

Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact

Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion

Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Ti-43.67Al-4Nb-0.1B-0.5W-1Cr at% + 200 ppm C Powder

Most important symptoms/effects, acute and delayed

Potential acute health effects
Inhalation : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Eye contact : No known significant effects or critical hazards.
Over-exposure signs/symptoms
Skin contact No specific data.
Ingestion No specific data
Inhalation No specific data
Eye contact : No specific data.

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary
Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments : No specific treatment.
Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.
See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media
Suitable extinguishing media: Use a Type D fire extinguisher for metal fires.
Unsuitable extinguishing media: Do not use water or foam. Do not use CO_2.
Specific hazards arising from the chemical: Flammable solid.
Hazardous thermal decomposition products: Decomposition products may include the following materials: metal oxide/oxides
Special protective actions for fire-fighters: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk.
Special protective equipment for fire-fighters: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
For non-emergency personnel:
No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders
If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill: Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber
brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Do not ingest. Avoid contact with eyes, skin and clothing. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use only non-sparking tools.
Empty containers retain product residue and can be hazardous. Do not reuse container.

Conditions for safe storage, including any incompatibilities

Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well ventilated area, away from incompatible materials (see section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters - Occupational exposure limits

Ingredient name	Exposure Limits
Aluminum	**NIOSH REL (United States)** TWA: 5 mg/m³ 10 hour(s). Form: Respirable fraction TWA: 10 mg/m³ 10 hour(s). Form: Total **OSHA PEL (United States)** TWA: 5 mg/m³, (as Al) 8 hour(s). Form: Respirable fraction TWA: 15 mg/m³, (as Al) 8 hour(s). Form: Total dust **ACGIH TLV (United States)** TWA: 1 mg/m³ 8 hour(s). Form: Respirable fraction
Chromium	**NIOSH REL (United States)** TWA: 0.5 mg/m³ **OSHA PEL (United States)** TWA: 1 mg/m³ **ACGIH TLV (United States)** TLV: 0.5 mg/m³
Niobium	**NIOSH REL (United States)** Not Established **OSHA PEL (United States)** Not Established **ACGIH TLV (United States)** Not Established
Tungsten	**NIOSH REL (United States)** TWA: 5 mg/m3 STEL: 10 mg/m3 **OSHA PEL (United States)** PEL: 10 mg/m3 **ACGIH TLV (United States)** 5 mg/m3
Boron	**ACGIH TLV (United States)** not available **NIOSH REL (United States)** TWA: 10 mg/m³ **OSHA PEL (United States)** TWA: 15 mg/m³ **ACGIH TLV TWA (United States)** TLV: 10 mg/m³

Iron	**NIOSH REL (United States)** Not Established **OSHA PEL (United States)** Not Established **ACGIH TLV (United States)** Not Established

Recommended monitoring procedures
If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Section 8. Exposure controls/personal protection

Appropriate engineering controls
Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls: Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures
Hygiene measures
Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.
Eye/face protection Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts.

Skin protection
Hand protection
Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Body protection Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection
Use a properly fitted, air-purifying or supplied air respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the

product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance
Physical state Solid. [Gray spherical powder]
Color Gray.
Odor Odorless.
Odor threshold Not available.
pH: Not available.
Melting point/freezing point: Not available
Boiling point/boiling range : Not available
Flash point Not available.
Evaporation rate Not available.
Flammability (solid, gas) : Not available.
Lower and upper explosive (flammable) limits: Not available.
Vapor pressure: Not available.
Relative density: Not available.
Vapor density: Not available.
Solubility: Insoluble in the following materials: cold water and hot water.
Partition coefficient: n-octanol/water Not available.
Auto-ignition temperature Not available.
Viscosity Not available.
SADT : Not available.
Decomposition temperature : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.
Chemical stability The product is stable.
Possibility of hazardous reactions: Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid Heat, flames, ignition sources and incompatibles.
Incompatible materials : Mineral acids, Molten alkali salt, Liquid oxygen, Oxides of Cu, Fe, Bi and some others. Carbon dioxide (CO_2).
Hazardous decomposition products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects
Acute toxicity
There is no data available.
Irritation/Corrosion
Skin : Not available.
Eyes : Not available.
Respiratory : Not available.
SensitizationThere is no data available.

Ti-43.67Al-4Nb-0.1B-0.5W-1Cr at% + 200 ppm C Powder

Carcinogenicity There is no data available.

	ACGIH	IARC	EPA	NIOSH	NTP	OSHA
Aluminum	A4	-	-	-	-	-
Chromium	A4	3	-	-	-	-
Niobium	A4	-	-	-	-	-
Tungsten	A4	-	-	-	-	-
Boron	A4	-	-	-	-	-
Iron	A4	-	-	-	-	-

Mutagenicity There is no data available.
Teratogenicity There is no data available.
Reproductive toxicity There is no data available.
Specific target organ toxicity (single exposure) There is no data available
Specific target organ toxicity (repeated exposure): There is no data available.
Aspiration hazard There is no data available.
Information on the likely routes of exposure: Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects
Eye contact : No known significant effects or critical hazards.
Inhalation : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics
Eye contact : No specific data.
Inhalation No specific data.
Skin contact: No specific data.
Ingestion: No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure
Potential immediate effects: Not available.
Potential delayed effects : Not available.

Long term exposure
Potential immediate effects: Not available.
Potential delayed effects: Not available.

Potential chronic health effects
General : No known significant effects or critical hazards.
Carcinogenicity : No known significant effects or critical hazards.
Mutagenicity : No known significant effects or critical hazards.
Teratogenicity : No known significant effects or critical hazards.
Developmental effects : No known significant effects or critical hazards.
Fertility effects : No known significant effects or critical hazards.
There is no data available.

Ti-43.67Al-4Nb-0.1B-0.5W-1Cr at% + 200 ppm C Powder

Numerical measures of toxicity
Acute toxicity estimates: There is no data available.

Section 12. Ecological information

Toxicity
There is no data available.
Persistence and degradability
There is no data available.
Bioaccumulative potential There is no data available.
Mobility in soil
Soil/water partition coefficient (K_{OC}): Not available.
Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods
The generation of waste should be avoided or minimized wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT	IMDG	IATA
UN number	NA	NA	NA
UN proper shipping name	NA	NA	NA
Transport Hazard Class(es)	NA	NA	NA
Packing Group	NA	NA	NA
Environmental Hazards	NA	NA	NA
Special Precautions for User	NA	NA	NA
Additional Information	-	-	-

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: Not available

Section 15. Regulatory information

Safety, health and environmental regulations specific for the product:
No known specific national and/or regional regulations applicable to this product (including its ingredients).

U.S. Federal regulations

TSCA 8(a) IUR Exempt/Partial exemption: Not determined
United States inventory (TSCA 8b): All components are listed or exempted.
SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Titanium; Aluminum; Vanadium
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Titanium: Fire hazard, Delayed (chronic) health hazard; Aluminum: Fire hazard, reactive
Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs): Not listed
Clean Air Act Section 602 Class I Substances : Not listed
Clean Air Act Section 602 Class II Substances : Not listed
DEA List I Chemicals (Precursor Chemicals) : Not listed
DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 313

	Product Name	CAS Number	Concentration (wt%)
Form R - Reporting Requirements	Aluminum Chromium	7429-90-5 7440-47-3	29.9-30.9 1.20-1.50
Supplier Notification	Aluminum Chromium	7429-90-5 7440-47-3	29.9-30.9 1.20-1.50

SARA 313 notifications must not be detached from the MSDS and any copying and redistribution of the MSDS shall include copying and redistribution of the notice attached to copies of the MSDS subsequently redistributed.

State regulations

Massachusetts The following components are listed: Aluminum
New York : None of the components are listed.
New Jersey : The following components are listed: Titanium; Aluminum
Pennsylvania : The following components are listed: Aluminum;
California Prop. 65: No products were found.

Ti-43.67Al-4Nb-0.1B-0.5W-1Cr at% + 200 ppm C Powder

Section 16. Other information

History

Date of issue mm/dd/yyyy: 11/01/2016

Version: NR

Prepared by : Puris, LLC

Key to abbreviations :

ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Ti-48Al-2Cr-2Nb Powder

SAFETY DATA SHEET

Section 1. Identification

Product identifier used on the label: Ti-48Al-2Cr-2Nb Powder
Other means of identification: Ti-33.4Al-2.7Cr-4.8Nb (weight basis)
Product type: Solid
Recommended use and restrictions
Identified uses: Not available.
Supplier's details :

Puris, LLC
78 Northpointe Dr.
Bruceton Mills, WV 26508
Phone: 304-777-4270
Fax: 304-842-1972

Emergency telephone number (with hours of operation): 304-777-4270 M-F 8AM-5PM

Section 2. Hazards identification

Classification of the substance or mixture: Not classified as flammable solid to CFR Title 49 Vol. 2 Appendix E
Ingredients of unknown toxicity: Not applicable
Ingredients of unknown ecotoxicity: Not applicable

GHS label elements
Hazard pictograms :
Signal word : Danger
Hazard statements : Flammable solid.
Precautionary statements
General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand. Further sieving of powder could result in classification of the powder as a flammable solid.
Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking.
Response : Not applicable.
Storage : Not applicable.
Disposal : Not applicable.
Other hazards which do not result in classification: Not available.

Section 3. Composition/information on ingredients

Substance/mixture: Mixture
Other means of identification : Titanium aluminide
CAS number/other identifiers
CAS number : Not applicable
EC number : Mixture.
Product code : Not available.

Ti-48Al-2Cr-2Nb Powder

Element	Percentage (wt%)	CAS Number
Titanium	57.7-60.6	7440-32-6
Aluminum	32.5-34.5	7429-90-5
Chromium	2.4-2.7	7440-47-3
Niobium	4.5-5.1	7440-03-1

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Eye contact

Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 20 minutes. Get medical attention if irritation occurs.

Inhalation

Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact

Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion

Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Inhalation : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.

Eye contact : No known significant effects or critical hazards.
Over-exposure signs/symptoms
Skin contact No specific data.
Ingestion No specific data
Inhalation No specific data
Eye contact : No specific data.

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary
Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments : No specific treatment.
Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. Itmay be dangerous to the person providing aid to give mouth-to-mouth resuscitation.
See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media
Suitable extinguishing media: Use a Type D fire extinguisher for metal fires.
Unsuitable extinguishing media: Do not use water or foam. Do not use CO_2.
Specific hazards arising from the chemical: Flammable solid.
Hazardous thermal decomposition products: Decomposition products may include the following materials: metal oxide/oxides
Special protective actions for fire-fighters: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk.
Special protective equipment for fire-fighters: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
For non-emergency personnel:
No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders
If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill: Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber
brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Do not ingest. Avoid contact with eyes, skin and clothing. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use only non-sparking tools.
Empty containers retain product residue and can be hazardous. Do not reuse container.

Conditions for safe storage, including any incompatibilities

Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well ventilated area, away from incompatible materials (see section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters - Occupational exposure limits

Ingredient name	Exposure Limits
Aluminum	**NIOSH REL (United States)**
	TWA: 5 mg/m³ 10 hour(s). Form: Respirable fraction
	TWA: 10 mg/m³ 10 hour(s). Form: Total
	OSHA PEL (United States)
	TWA: 5 mg/m³, (as Al) 8 hour(s). Form: Respirable fraction

	TWA: 15 mg/m³, (as Al) 8 hour(s). Form: Total dust
	ACGIH TLV (United States)
	TWA: 1 mg/m³ 8 hour(s). Form: Respirable fraction
Chromium	**NIOSH REL (United States)**
	TWA: 0.5 mg/m³
	OSHA PEL (United States)
	TWA: 1 mg/m³
	ACGIH TLV (United States)
	TLV: 0.5 mg/m³
Niobium	**TWA NOT ESTABLISHED**
	TLV NOT ESTABLISHED

Recommended monitoringprocedures
If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Section 8. Exposure controls/personal protection

Appropriate engineering controls
Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls: Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures
Hygiene measures
Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.
Eye/face protection Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts.

Skin protection
Hand protection
Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Body protection Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Other skin protection : Appropriate footwear and any additional skin protection measures should be

selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection
Use a properly fitted, air-purifying or supplied air respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance
Physical state Solid. [Gray spherical powder]
Color Gray.
Odor Odorless.
Odor threshold Not available.
pH: Not available.
Melting point/freezing point: 1500°C (2732°F)
Boiling point/boiling range : 3200°C (5792°F)
Flash point Not available.
Evaporation rate Not available.
Flammability (solid, gas) : Not available.
Lower and upper explosive (flammable) limits: Not available.
Vapor pressure: Not available.
Relative density: 4.5
Vapor density: Not available.
Solubility: Insoluble in the following materials: cold water and hot water.
Partition coefficient: n-octanol/water Not available.
Auto-ignition temperature Not available.
Viscosity Not available.
SADT : Not available.
Decomposition temperature : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.
Chemical stability The product is stable.
Possibility of hazardous reactions: Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid Heat, flames, ignition sources and incompatibles.
Incompatible materials : Mineral acids, Molten alkali salt, Liquid oxygen, Oxides of Cu, Fe, Bi and some others. Carbon dioxide (CO_2).
Hazardous decomposition products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects
Acute toxicity
There is no data available.
Irritation/Corrosion

Ti-48Al-2Cr-2Nb Powder

Skin : Not available.
Eyes : Not available.
Respiratory : Not available.
SensitizationThere is no data available.

Carcinogenicity There is no data available.

	ACGIH	IARC	EPA	NIOSH	NTP	OSHA
Aluminum	A4	-	-	-	-	-
Chromium	A4	3	-	-	-	-
Niobium	A4	-	-	-	-	-

Mutagenicity There is no data available.
Teratogenicity There is no data available.
Reproductive toxicity There is no data available.
Specific target organ toxicity (single exposure) There is no data available
Specific target organ toxicity (repeated exposure): There is no data available.
Aspiration hazard There is no data available.
Information on the likely routes of exposure: Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects
Eye contact : No known significant effects or critical hazards.
Inhalation : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics
Eye contact : No specific data.
Inhalation No specific data.
Skin contact: No specific data.
Ingestion: No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure
Potential immediate effects: Not available.
Potential delayed effects : Not available.

Long term exposure
Potential immediate effects: Not available.
Potential delayed effects: Not available.

Potential chronic health effects
General : No known significant effects or critical hazards.
Carcinogenicity : No known significant effects or critical hazards.
Mutagenicity : No known significant effects or critical hazards.
Teratogenicity : No known significant effects or critical hazards.
Developmental effects : No known significant effects or critical hazards.
Fertility effects : No known significant effects or critical hazards.
There is no data available.

Numerical measures of toxicity
Acute toxicity estimates: There is no data available.

Section 12. Ecological information

Toxicity
There is no data available.
Persistence and degradability
There is no data available.
Bioaccumulative potential There is no data available.
Mobility in soil
Soil/water partition coefficient (K_{OC}): Not available.
Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods
The generation of waste should be avoided or minimized wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT	IMDG	IATA
UN number	NA	NA	NA
UN proper shipping name	NA	NA	NA
Transport Hazard Class(es)	NA	NA	NA
Packing Group	NA	NA	NA
Environmental Hazards	NA	NA	NA
Special Precautions for User	NA	NA	NA
Additional Information	-	-	-

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: Not available

Section 15. Regulatory information

Safety, health and environmental regulations specific for the product:
No known specific national and/or regional regulations applicable to this product (including its ingredients).

U.S. Federal regulations

TSCA 8(a) IUR Exempt/Partial exemption: Not determined
United States inventory (TSCA 8b): All components are listed or exempted.
SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Titanium; Aluminum; Vanadium
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Titanium: Fire hazard, Delayed (chronic) health hazard; Aluminum: Fire hazard, reactive
Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs): Not listed
Clean Air Act Section 602 Class I Substances : Not listed
Clean Air Act Section 602 Class II Substances : Not listed
DEA List I Chemicals (Precursor Chemicals) : Not listed
DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 313

	Product Name	CAS Number	Concentration (wt%)
Form R - Reporting Requirements	Aluminum	7429-90-5	32.5-34.5
	Chromium	7440-47-3	2.4-2.7
	Niobium	7440-03-1	4.5-5.1
Supplier Notification	Aluminum	7429-90-5	32.5-34.5
	Chromium	7440-47-3	2.4-2.7
	Niobium	7440-03-1	4.5-5.1

SARA 313 notifications must not be detached from the MSDS and any copying and redistribution of the MSDS shall include copying and redistribution of the notice attached to copies of the MSDS subsequently redistributed.

State regulations

Massachusetts The following components are listed: Aluminum
New York : None of the components are listed.
New Jersey : The following components are listed: Titanium; Aluminum
Pennsylvania : The following components are listed: Aluminum;
California Prop. 65: No products were found.

Section 16. Other information

History

Date of issue mm/dd/yyyy: 05/19/2016

Version: 2

Prepared by : Puris, LLC

Key to abbreviations :

ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

Notice to reader

To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Titanium Aluminide

SAFETY DATA SHEET

Section 1. Identification

Product identifier used on the label: Titanium Aluminide
Other means of identification: TiAl
Product type: Solid
Recommended use and restrictions
Identified uses: Not available.
Supplier's details :

Puris, LLC
78 Northpointe Dr.
Bruceton Mills, WV 26508
Phone: 304-777-4270
Fax: 304-842-1972

Emergency telephone number (with hours of operation): 304-777-4270 M-F 8AM-5PM

Section 2. Hazards identification

Classification of the substance or mixture: Not applicable
Ingredients of unknown toxicity: Not applicable
Ingredients of unknown ecotoxicity: Not applicable

GHS label elements
Hazard pictograms :
Signal word : Danger
Hazard statements : Flammable solid in powder form.
Precautionary statements
General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking.
Response : Not applicable.
Storage : Not applicable.
Disposal : Not applicable.
Other hazards which do not result in classification: Not available.

Section 3. Composition/information on ingredients

Substance/mixture: Mixture
Other means of identification : Titanium aluminide
CAS number/other identifiers
CAS number : Not applicable
EC number : Mixture.
Product code : Not available.

Titanium Aluminide

Element	Percentage (wt%)	CAS Number
Titanium	60-70	7440-32-6
Aluminum	30-40	7429-90-5

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Eye contact
Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 20 minutes. Get medical attention if irritation occurs.

Inhalation
Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact
Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion
Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects
Inhalation : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Eye contact : No known significant effects or critical hazards.

Over-exposure signs/symptoms
Skin contact No specific data.

Titanium Aluminide

Ingestion No specific data
Inhalation No specific data
Eye contact : No specific data.

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary
Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments : No specific treatment.
Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. Itmay be dangerous to the person providing aid to give mouth-to-mouth resuscitation.
See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media
Suitable extinguishing media: Use a Type D fire extinguisher for metal fires.
Unsuitable extinguishing media: Do not use water or foam. Do not use CO_2.
Specific hazards arising from the chemical: Flammable solid.
Hazardous thermal decomposition products: Decomposition products may include the following materials: metal oxide/oxides
Special protective actions for fire-fighters: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk.
Special protective equipment for fire-fighters: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
For non-emergency personnel:
No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders
If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up
Small spill: Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber
brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to

accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Do not ingest. Avoid contact with eyes, skin and clothing. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use only non-sparking tools.
Empty containers retain product residue and can be hazardous. Do not reuse container.

Conditions for safe storage, including any incompatibilities

Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well ventilated area, away from incompatible materials (see section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters - Occupational exposure limits

Ingredient name	Exposure Limits
Aluminum	**NIOSH REL (United States)**
	TWA: 5 mg/m³ 10 hour(s). Form: Respirable fraction
	TWA: 10 mg/m³ 10 hour(s). Form: Total
	OSHA PEL (United States)
	TWA: 5 mg/m³, (as Al) 8 hour(s). Form: Respirable fraction
	TWA: 15 mg/m³, (as Al) 8 hour(s). Form: Total dust
	ACGIH TLV (United States)
	TWA: 1 mg/m³ 8 hour(s). Form: Respirable fraction

Recommended monitoring procedures
If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Section 8. Exposure controls/personal protection
Appropriate engineering controls
Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls: Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures
Hygiene measures
Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.
Eye/face protection Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts.

Skin protection
Hand protection
Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Body protection Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection
Use a properly fitted, air-purifying or supplied air respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Titanium Aluminide

Section 9. Physical and chemical properties

Appearance
Physical state Solid. [Gray spherical powder]
Color Gray.
Odor Odorless.
Odor threshold Not available.
pH: Not available.
Melting point/freezing point: 1668°C (3034°F)
Boiling point/boiling range : Not available
Flash point Not available.
Evaporation rate Not available.
Flammability (solid, gas) : Not available.
Lower and upper explosive (flammable) limits: Not available.
Vapor pressure: Not available.
Relative density: 4.0
Vapor density: Not available.
Solubility: Insoluble in the following materials: cold water and hot water.
Partition coefficient: n-octanol/water Not available.
Auto-ignition temperature Not available.
Viscosity Not available.
SADT : Not available.
Decomposition temperature : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.
Chemical stability The product is stable.
Possibility of hazardous reactions: Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid Heat, flames, ignition sources and incompatibles.
Incompatible materials : Mineral acids, Molten alkali salt, Liquid oxygen, Oxides of Cu, Fe, Bi and some others. Carbon dioxide (CO_2).
Hazardous decomposition products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects
Acute toxicity
There is no data available.
Irritation/Corrosion
Skin : Not available.
Eyes : Not available.
Respiratory : Not available.
SensitizationThere is no data available.

Carcinogenicity There is no data available.

	ACGIH	IARC	EPA	NIOSH	NTP	OSHA
Aluminum	A4	-	-	-	-	-

Titanium Aluminide

Mutagenicity There is no data available.
Teratogenicity There is no data available.
Reproductive toxicity There is no data available.
Specific target organ toxicity (single exposure) There is no data available
Specific target organ toxicity (repeated exposure): There is no data available.
Aspiration hazard There is no data available.
Information on the likely routes of exposure: Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects
Eye contact : No known significant effects or critical hazards.
Inhalation : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics
Eye contact : No specific data.
Inhalation No specific data.
Skin contact: No specific data.
Ingestion: No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure
Potential immediate effects: Not available.
Potential delayed effects : Not available.

Long term exposure
Potential immediate effects: Not available.
Potential delayed effects: Not available.

Potential chronic health effects
General : No known significant effects or critical hazards.
Carcinogenicity : No known significant effects or critical hazards.
Mutagenicity : No known significant effects or critical hazards.
Teratogenicity : No known significant effects or critical hazards.
Developmental effects : No known significant effects or critical hazards.
Fertility effects : No known significant effects or critical hazards.
There is no data available.

Numerical measures of toxicity
Acute toxicity estimates: There is no data available.

Section 12. Ecological information

Toxicity
There is no data available.
Persistence and degradability
There is no data available.
Bioaccumulative potential There is no data available.
Mobility in soil
Soil/water partition coefficient (K_{OC}): Not available.

Titanium Aluminide

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods

The generation of waste should be avoided or minimized wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT	IMDG	IATA
UN number	NA	NA	NA
UN proper shipping name	NA	NA	NA
Transport Hazard Class(es)	NA	NA	NA
Packing Group	NA	NA	NA
Environmental Hazards	NO	NO	NO
Special Precautions for User	NA	NA	NA
Additional Information	-	-	-

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: Not available

Section 15. Regulatory information

Safety, health and environmental regulations specific for the product:

No known specific national and/or regional regulations applicable to this product (including its ingredients).

U.S. Federal regulations

TSCA 8(a) IUR Exempt/Partial exemption: Not determined
United States inventory (TSCA 8b): All components are listed or exempted.
SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Titanium; Aluminum; Vanadium
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Titanium: Fire hazard, Delayed (chronic) health hazard; Aluminum: Fire hazard, reactive

Titanium Aluminide

Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs): Not listed
Clean Air Act Section 602 Class I Substances : Not listed
Clean Air Act Section 602 Class II Substances : Not listed
DEA List I Chemicals (Precursor Chemicals) : Not listed
DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 313

	Product Name	CAS Number	Concentration (wt%)
Form R - Reporting Requirements	Aluminum	7429-90-5	30-40
Supplier Notification	Aluminum	7429-90-5	33.4

SARA 313 notifications must not be detached from the MSDS and any copying and redistribution of the MSDS shall include copying and redistribution of the notice attached to copies of the MSDS subsequently redistributed.

State regulations
Massachusetts The following components are listed: Aluminum
New York : None of the components are listed.
New Jersey : The following components are listed: Titanium; Aluminum
Pennsylvania : The following components are listed: Aluminum;
California Prop. 65: No products were found.

Section 16. Other information

History
Date of issue mm/dd/yyyy: 09/12/2014
Version: 1
Prepared by : Puris, LLC.
Key to abbreviations :
ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

Notice to reader
To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Zr 702 Powder

SAFETY DATA SHEET

Section 1. Identification

Product identifier used on the label: Zr 702 Powder
Other means of identification: Zircadyne 702 Powder
Product type: Solid
Recommended use and restrictions
Identified uses: Not available.
Supplier's details :

Puris, LLC
78 Northpointe Dr.
Bruceton Mills, WV 26508
Phone: 304-777-4270
Fax: 304-842-1972

Emergency telephone number (with hours of operation): 304-777-4270 M-F 8AM-5PM

Section 2. Hazards identification

Classification of the substance or mixture: Not classified as flammable solid to CFR Title 49 Vol. 2 Appendix E
Ingredients of unknown toxicity: Not applicable
Ingredients of unknown ecotoxicity: Not applicable

GHS label elements

Hazard pictograms : GHS02
Signal word : Danger
Hazard statements : H261 – In contact with water releases flammable gases

Precautionary statements
General : Not applicable.
Prevention : P210 – Keep away from heat/sparks/open flames/hot surfaces. No smoking.
P240 – Ground/bond container and receiving equipment.
P261 – Avoid breathing dust.
Response : P370 – In case of fire, use Type D fire extinguisher
Storage : Not applicable.
Disposal : P501 – Dispose of contents/container in accordance with local/regional/national/international regulations
Other hazards which do not result in classification: Not available.

Section 3. Composition/information on ingredients

Substance/mixture: Mixture
Other means of identification : Metal Powder
CAS number/other identifiers
CAS number : Not applicable

Zr 702 Powder

EC number : Mixture.
Product code : Not available.

Element	Percentage (wt%)	CAS Number
Zirconium	95.5-99.2	7440-67-7
Hafnium	4.5 max	7440-58-6

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Eye contact
Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 20 minutes. Get medical attention if irritation occurs.

Inhalation
Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact
Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion
Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects
Inhalation : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.

Skin contact : No known significant effects or critical hazards.
Eye contact : No known significant effects or critical hazards.
Over-exposure signs/symptoms
Skin contact No specific data.
Ingestion No specific data
Inhalation No specific data
Eye contact : No specific data.

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary
Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments : No specific treatment.
Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation.
See toxicological information (Section 11)

Section 5. Fire-fighting measures

As supplied, the product is not classified as flammable solid to CFR Title 49 Vol. 2 Appendix E. Sieving of the product to finer sizes may increase its flammability.

Extinguishing media
Suitable extinguishing media: Use a Type D fire extinguisher or dry sand for metal fires.
Unsuitable extinguishing media: Do not use water or foam. Do not use CO_2.
Specific hazards arising from the chemical: Flammable solid.
Hazardous thermal decomposition products: Decomposition products may include the following materials: metal oxide/oxides
Special protective actions for fire-fighters: Dispersed dust clouds may form explosive mixtures in air. Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk.
Special protective equipment for fire-fighters: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
For non-emergency personnel:
No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Avoid formation of dust. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders
If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental

pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill: Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber
brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Do not ingest. Avoid contact with eyes, skin and clothing. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use only non-sparking tools.
Empty containers retain product residue and can be hazardous. Do not reuse container.

Conditions for safe storage, including any incompatibilities

Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well ventilated area, away from incompatible materials (see section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters - Occupational exposure limits

Ingredient name	Exposure Limits
Zirconium	**NIOSH REL (United States)** TWA: 5 mg/m³ STEL: 10 mg/m³
	OSHA PEL (United States) TWA: 5 mg/m³
	ACGIH TLV (United States) TWA: 5 mg/m³
Hafnium	**NIOSH REL (United States)** TWA: 0.5 mg/m³
	OSHA PEL (United States) TWA: 0.5 mg/m³
	ACGIH TLV (United States) TLV: 0.5 mg/m³

Recommended monitoring procedures

If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Section 8. Exposure controls/personal protection

Appropriate engineering controls

Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls: Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures

Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts.

Skin protection

Hand protection

Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.

Body protection Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection

Use a properly fitted, air-purifying or supplied air respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance

Physical state Solid. [Gray spherical powder]

Color Gray.

Odor Odorless.

Odor threshold Not available.

pH: Not available.

Melting point/freezing point: 1852°C 3366°F)

Boiling point/boiling range : Not available.

Flash point Not available.

Evaporation rate Not available.

Flammability (solid, gas) : Not available.

Lower and upper explosive (flammable) limits: Not available.

Vapor pressure: 0.01 mm Hg at 2000°C. 900 mm Hg at 3600°C

Relative density: 6.51

Vapor density: Not available.

Solubility: Insoluble in the following materials: cold water and hot water.

Partition coefficient: n-octanol/water Not available.

Auto-ignition temperature Not available.

Viscosity Not available.

SADT : Not available.

Decomposition temperature : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Zr 702 Powder

Chemical stability The product reacts with water to form hydrogen gas. Finely divided powders can spontaneously ignite in air.
Possibility of hazardous reactions: Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid Heat, flames, ignition sources, and incompatibles.
Incompatible materials : Mineral acids, Water, Molten alkali salt, Liquid oxygen, Oxides of Cu, Fe, Bi and some others. Carbon dioxide (CO_2).
Hazardous decomposition products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects
Acute toxicity
There is no data available.
Irritation/Corrosion
Skin : Not available.
Eyes : Not available.
Respiratory : Not available.
SensitizationThere is no data available.

Carcinogenicity There is no data available.

	ACGIH	IARC	EPA	NIOSH	NTP	OSHA
Zirconium	A4	-	-	-	-	-
Hafnium	A4	-	-	-	-	-

Mutagenicity There is no data available.
Teratogenicity There is no data available.
Reproductive toxicity There is no data available.
Specific target organ toxicity (single exposure) There is no data available
Specific target organ toxicity (repeated exposure): There is no data available.
Aspiration hazard There is no data available.
Information on the likely routes of exposure: Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects
Eye contact : No known significant effects or critical hazards.
Inhalation : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics
Eye contact : No specific data.
Inhalation No specific data.
Skin contact: No specific data.
Ingestion: No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure
Potential immediate effects: Not available.

Zr 702 Powder

Potential delayed effects : Not available.

Long term exposure
Potential immediate effects: Not available.
Potential delayed effects: Not available.

Potential chronic health effects
General : No known significant effects or critical hazards.
Carcinogenicity : No known significant effects or critical hazards.
Mutagenicity : No known significant effects or critical hazards.
Teratogenicity : No known significant effects or critical hazards.
Developmental effects : No known significant effects or critical hazards.
Fertility effects : No known significant effects or critical hazards.
There is no data available.

Numerical measures of toxicity
Acute toxicity estimates: There is no data available.

Section 12. Ecological information

Toxicity
There is no data available.
Persistence and degradability
There is no data available.
Bioaccumulative potential There is no data available.
Mobility in soil
Soil/water partition coefficient (K_{OC}): Not available.
Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods
The generation of waste should be avoided or minimized wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT	IMDG	IATA
UN number	NA	NA	NA
UN proper shipping name	NA	NA	NA
Transport Hazard Class(es)	NA	NA	NA
Packing Group	NA	NA	NA
Environmental Hazards	NA	NA	NA
Special Precautions for User	NA	NA	NA
Additional Information	-	-	-

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: Not available

Section 15. Regulatory information

Safety, health and environmental regulations specific for the product:
No known specific national and/or regional regulations applicable to this product (including its ingredients).

U.S. Federal regulations

TSCA 8(a) IUR Exempt/Partial exemption: Not determined
United States inventory (TSCA 8b): All components are listed or exempted.
SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: No products were found
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Zirconium: Fire hazard, reactive
Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs): Not listed
Clean Air Act Section 602 Class I Substances : Not listed
Clean Air Act Section 602 Class II Substances : Not listed
DEA List I Chemicals (Precursor Chemicals) : Not listed
DEA List II Chemicals (Essential Chemicals) : Not listed

Zr 702 Powder

SARA 313

Form R Reporting Requirements and Supplier Notification	Element	Percentage (wt%)	CAS Number
	Zirconium	95.5-99.2	7440-67-7
	Hafnium	4.5 max	7440-58-6

SARA 313 notifications must not be detached from the MSDS and any copying and redistribution of the MSDS shall include copying and redistribution of the notice attached to copies of the MSDS subsequently redistributed.

State regulations
Massachusetts None of the components are listed
New York : None of the components are listed.
New Jersey : None of the components are listed
Pennsylvania : None of the components are listed
California Prop. 65: No products were found.

Section 16. Other information

History
Date of issue mm/dd/yyyy: 07/06/2016
Version: 1
Prepared by : Puris, LLC
Key to abbreviations :
ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

Notice to reader
To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

Material Safety Data Sheet

Material Name: PURIS, LLC SM-100™ **MSDS ID: SM-100**

* * * Section 1 - Chemical Product and Company Identification * * *

Chemical Name: Mixture
Product Use: SM-100, NiTiNOL
Manufacturer Information

Puris, LLC
78 Northpointe Drive
Bruceton Mills, WV 26525

Emergency #: 304.777.4270
Mfg Contact: Fred Yolton

General Comments

THIS MSDS APPLIES TO ALL ESTABLISHED NITIONOL GRADES MANUFACTURERED BY PURIS, LLC. SPECIFIC PERCENT COMPONENTS FOR EACH ELEMENT CAN BE OBTAINED FROM THE CERTIFICATE OF TEST.

* * * Section 2 - Hazards Identification * * *

Emergency Overview

Product contains nickel and titanium metal. Dusts from this product may pose a dust explosion hazard. Contact of molten product with water can cause an explosion hazard. Firefighters should wear a positive pressure self-contained breathing apparatus with full facepiece.

Potential Health Effects: Eyes

Dust or powder may be irritating to the eyes. Rubbing may cause abrasion of the cornea.

Potential Health Effects: Skin

Dust or powder may irritate the skin. Rubbing may increase mechanical irritation to the skin. Product contains nickel, which may cause an allergic skin reaction. No components of this product are known to be absorbed through the skin.

Potential Health Effects: Ingestion

Dusts or powders may cause temporary irritation of the throat, stomach and gastrointestinal tract.

Potential Health Effects: Inhalation

Dusts and powders from this product may cause irritation to the nasal passages and respiratory tract. When inhaled in very large amounts, damage to the lung may occur. Dusts, particulates or fumes that may be produced may contain metals that cause metal fume fever, a transitory condition including fever, chills, aches, cough and general malaise. Repeated exposure may lead to respiratory sensitization reactions, producing an asthma-like condition.

HMIS Ratings: Health: 1* **Fire:** 0 **Reactivity:** 0 **Pers. Prot.:** safety glasses, gloves
Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe * = Chronic hazard

* * * Section 3 - Composition / Information on Ingredients * * *

CAS #	Component	Percent
7440-02-0	Nickel*	50-100
7440-32-6	Titanium	0-50

Component Related Regulatory Information

This product may be regulated, have exposure limits or other information identified as the following: Nickel compounds, Titanium compounds, welding fumes.

Component Information/Information on Non-Hazardous Components

This material is considered hazardous under 29 CFR 1910.1200 (Hazard Communication) and the Canadian Controlled Products Regulations. The information in this MSDS is provided for situations creating dusts or fumes which may be potentially hazardous.

* This component is subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and of 40 CFR 372:

Please note that if you repackage or otherwise redistribute this product to industrial customers, a notice similar to this one must be sent to those customers.

* * * Section 4 - First Aid Measures * * *

First Aid: Eyes

For contact with dusts or particulates, flush eyes with water for 15 minutes. Eye injuries from solid particles should be treated by a physician immediately.

First Aid: Skin

For skin contact with dusts or powders, wash immediately with soap and water. Cuts or abrasions should be treated promptly with thorough cleansing of the affected area.

First Aid: Ingestion

No need for first aid is anticipated if material is swallowed, however if symptoms develop, seek medical attention.

First Aid: Inhalation

If large amounts of dusts, fumes or particulates are generated, move person to fresh air. If symptoms develop, seek medical attention.

First Aid: Notes to Physician

Respiratory disorders may be aggravated by exposure to metallic dusts or fumes.

* * * Section 5 - Fire Fighting Measures * * *

General Fire Hazards

See Section 9 for Flammability Properties.

This material will not burn. Fine dusts of this material mixed with oxygen and a suitable source of ignition my pose an explosion hazard.

Hazardous Combustion Products

Material will begin softening at approximately 2100 °F (1149 °C) will proceed to a liquid and will form irritating and toxic gaseous metallic oxides at extremely high temperatures.

Extinguishing Media

Use methods for the surrounding fire. Use a Class D extinguisher for metal powder fires.

Unsuitable Extinguishing Media

Water may react with metal dust or powder and release flammable hydrogen gas.

Fire Fighting Equipment/Instructions

Firefighters should wear full-face, self contained breathing apparatus and impervious protective clothing.

NFPA Ratings: Health: 1 **Fire:** 0 **Reactivity:** 0
Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe

* * * Section 6 - Accidental Release Measures * * *

Containment Procedures

Containment of this material should not be necessary. If dusts or particulates are generated, eliminate sources of ignition.

Clean-Up Procedures

Small pieces of this product may be collected with a broom and shovel. Dusts and particulates may be collected by using a vacuum with a HEPA filter. If sweeping of a contaminated area is necessary, use a dust suppressant agent. Place collected material in a closed container.

Evacuation Procedures

Isolate area. Keep unnecessary personnel away.

Special Procedures

None necessary.

* * * Section 7 - Handling and Storage * * *

Handling Procedures

Avoid generating dusts or particulates. Avoid inhalation of dusts, particulates or fumes. Avoid contact of dusts or particulates with eyes or skin. Wash thoroughly after handling.

Storage Procedures

Store in a dry area.

*** Section 8 - Exposure Controls / Personal Protection ***

Exposure Guidelines

A: General Product Information

Follow all applicable exposure limits.

B: Component Exposure Limits:

Nickel (7440-02-0)

ACGIH:	1.5 mg/m3 TWA (inhalable fraction)
OSHA:	1 mg/m3 TWA
NIOSH:	0.015 mg/m3 TWA

C: Component Exposure Limits (Canada):

Nickel (7440-02-0)

Alberta:	1.5 mg/m3 TWA
British Columbia:	0.05 mg/m3 TWA
Manitoba:	1.5 mg/m3 TWA (inhalable fraction)
New Brunswick:	1 mg/m3 TWA
Newfoundland:	1.5 mg/m3 TWA (inhalable fraction)
Northwest Territories:	1.5 mg/m3 TWA (inhalable fraction)
Nova Scotia:	1.5 mg/m3 TWA (inhalable fraction)
Nunavut:	2 mg/m3 STEL 1 mg/m3 TWA
Ontario:	1 mg/m3 TWAEV (inhalable)
Prince Edward Island:	1.5 mg/m3 TWA (inhalable fraction)
Quebec:	1 mg/m3 TWAEV
Saskatchewan:	3 mg/m3 STEL (inhalable fraction) 1.5 mg/m3 TWA (inhalable fraction)
Yukon:	3 mg/m3 STEL 1 mg/m3 TWA

Engineering Controls

Whenever dusts, particulates or fumes are generated, use appropriate local exhaust ventilation to keep exposures below the regulated limits.

PERSONAL PROTECTIVE EQUIPMENT

Personal Protective Equipment: Eyes/Face

Wear safety glasses with side shields.

Personal Protective Equipment: Skin

Wear leather or other appropriate gloves, if necessary for the type of operation.

Personal Protective Equipment: Respiratory

When dusts or thermal processing fumes are generated and ventilation is not sufficient to effectively remove them, appropriate NIOSH approved respiratory protection must be provided.

Personal Protective Equipment: General

Use good industrial hygiene practices in handling this material.

*** Section 9 - Physical & Chemical Properties ***

Appearance:	Gray	**Odor:**	None
Physical State:	Solid (metal/powder)	**pH:**	Not applicable
Vapor Pressure:	Not applicable	**Vapor Density:**	Not applicable
Boiling Point:	Not available	**Melting Point:**	2100 - 3000 °F (1149 - 1649 °C)
Solubility (H2O):	Insoluble	**Specific Gravity:**	6.1-9.1 (water=1)
Softening Point:	2100 °F (1149 °C)	**Flash Point**	Not applicable
Flash Point Method	Not applicable	**LFL**	Not applicable
UFL	Not applicable		

* * * Section 10 - Chemical Stability & Reactivity Information * * *

Chemical Stability
Product is stable.

Chemical Stability: Conditions to Avoid
Avoid exposure to generated dust and/or fume.

Incompatibility
Product reacts with strong acids to generate hydrogen gas.

Hazardous Decomposition
Material will begin softening at approximately 2100 °F (1149 °C), will proceed to a liquid and will form irritating and toxic gaseous metallic oxides at extremely high temperatures.

Possibility of Hazardous Reactions
Will not occur.

* * * Section 11 - Toxicological Information * * *

Acute Dose Effects

A: General Product Information

If this product is shipped in a powder form or operations which supply sufficient energy to the product (i.e. welding, high speed grinding or melting) release dust or fumes it may make components of the product biologically available.

Exposure to dusts or fumes from some metals including iron, chromium, and copper can produce a condition known as metal fume fever, a flu-like illness with nausea, vomiting, chest tightness, muscle aches and weakness. The symptoms come on a few hours after excessive exposures and usually last from 12 to 48 hours. Long-term effects from metal fume fever have not been noted.

NICKEL: Nickel fumes are respiratory irritants and have been a known cause of asthma, pneumonia, pulmonary edema and pulmonary fibrosis in welders using nickel alloys. Airborne nickel-contaminated dusts are regarded as capable of producing lung cancer. The risk is higher for workers at primary nickel smelters and refineries than for workers exposed to nickel alloys. Skin contact may cause an allergic rash. Nickel itch is the dermatitis resulting from sensitization to nickel. Itching can occur up to seven days before skin eruption occurs. The primary skin eruption is reddening or infection of the hair follicles, which may be followed by skin ulceration. Nickel sensitivity, once acquired, is apparently not lost.

TITANIUM: Elemental titanium is an inert material. Titanium dioxide may be generated in welding fumes from this product. At extremely high concentrations, titanium dioxide has induced lung cancer in rats. Titanium dioxide dust is a mild pulmonary, eye and skin irritant: Rats exposed to titanium dioxide developed small focal areas of emphysema which were attributable to large deposits of dust. Excessive exposure in humans may result in slight changes in the lungs. The dusts of titanium dioxide can be placed in the nuisance category.

B: Component Analysis - LD50/LC50

Nickel (7440-02-0)

Oral LD50 Rat: >9000 mg/kg

Epidemiology
No information available for the product.

Carcinogenicity

A: General Product Information

No information available for the product.

Occupational exposure to nickel dusts or fumes increases the risk of respiratory cancers.

B: Component Carcinogenicity

Nickel (7440-02-0)

ACGIH: A5 - Not Suspected as a Human Carcinogen
NIOSH: potential occupational carcinogen
NTP: Known Human Carcinogen (related to Nickel compounds) (Select Carcinogen)
Reasonably Anticipated To Be A Human Carcinogen (Possible Select Carcinogen)
IARC: Monograph 49 [1990] (evaluated as a group) (related to Nickel compounds) (Group 1 (carcinogenic to humans))

Mutagenicity

No information available for the product.

Nickel inhibited DNA repair and induced transformation in experimental assays.

Teratogenicity

No information available for the product.

Chromium, copper and nickel have been reported to have adverse reproductive effects in experimental animals.

Chromium, copper and nickel have been shown to be fetotoxic in experimental animals.

Neurological Effects

No information available for the product.

Other Toxicological Information

None identified.

* * * Section 12 - Ecological Information * * *

Ecotoxicity

A: General Product Information

No information available for the product.

B: Component Analysis - Ecotoxicity - Aquatic Toxicity

Nickel (7440-02-0)

Test & Species		Conditions
96 Hr LC50 Brachydanio rerio	>100 mg/L	
72 Hr EC50 freshwater algae (4 species)	0.1 mg/L	
72 Hr EC50 Selenastrum capricornutum	0.18 mg/L	
96 Hr EC50 water flea	510 µg/L	

Environmental Fate

No information available for the product.

* * * Section 13 - Disposal Considerations * * *

Disposal Instructions

This product is not regulated as a hazardous waste by the federal EPA. Collected dusts and other similar wastes generated during processing of the product could contain a constituent identified as hazardous under 40 CFR § 261.24.

See Section 7 for Handling Procedures. See Section 8 for Personal Protective Equipment recommendations.

* * * Section 14 - Transportation Information * * *

International Transportation Regulations

Not regulated as dangerous goods.

US DOT Information

Shipping Name: Not regulated as dangerous goods.
UN/NA #: None **Hazard Class:** None **Packing Group:** None
Required Label(s): None
Additional Info.: None

TDG Information

Shipping Name: Not regulated as dangerous goods.
UN/NA #: None **Hazard Class:** None **Packing Group:** None
Required Label(s): None
Additional Info.: None

* * * Section 15 - Regulatory Information * * *

US Federal Regulations

A: General Product Information

No information available for the product.

B: Component Analysis

This material contains one or more of the following chemicals required to be identified under SARA Section 302 (40 CFR 355 Appendix A) and/or CERCLA (40 CFR 302.4).

Nickel (7440-02-0)

SARA 313: 0.1 % de minimis concentration
CERCLA: 100 lb final RQ (no reporting of releases of this hazardous substance is required if the diameter of the pieces of the solid metal released is larger than 100 micrometers); 45.4 kg final RQ (no reporting of releases of this hazardous substance is required if the diameter of the pieces of the solid metal released is larger than 100 micrometers)

State Regulations

A: General Product Information

Other state regulations may apply. Check individual state requirements.

B: Component Analysis - State

The following components appear on one or more of the following state hazardous substances lists:

Component	CAS #	CA	FL	MA	MN	NJ	PA
Nickel	7440-02-0	Yes	No	Yes	Yes	Yes	Yes
Titanium	7440-32-6	Yes	No	No	No	Yes	No

The following statement(s) are provided under the California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65):
WARNING! This product contains a chemical known to the state of California to cause cancer.

The following statement(s) are provided under the California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65):

WARNING! This product contains a chemical known to the state of California to cause cancer.

Canadian WHMIS Information

A: General Product Information

For the product as supplied, the following classification applies:

D2A, D2B Materials Causing Other Toxic Effects

B: Component Analysis - WHMIS IDL

The following components are identified under the Canadian Hazardous Products Act Ingredient Disclosure List:

Component	CAS #	Minimum Concentration
Nickel	7440-02-0	0.1 %

Additional Regulatory Information

A: General Product Information

No information available for the product.

* * * Section 16 - Other Information * * *

Other Information

Reasonable care has been taken in the preparation of this information, but the manufacturer makes no warranty of merchantability or any other warranty, expressed or implied, with respect to this information. The manufacturer makes no representations and assumes no liability for any direct, incidental or consequential damages resulting from its use.

Coatings may be applied to the product for protective purposes. The possible presence of coatings should be recognized and considered when evaluating potential employee hazards and exposures during dust- and fume-generating activities.

Key/Legend

ACGIH = American Conference of Governmental Industrial Hygienists. CERCLA = Comprehensive Environmental Response, Compensation and Liability Act. CFR = Code of Federal Regulations. DSL = Canadian Domestic Substance List. EINECS = European Inventory of New and Existing Chemical Substances. EPA = Environmental Protection Agency. HEPA = High Efficiency Particulate Air. HMIS = Hazardous Material Information System. IARC = International Agency for Research on Cancer. NFPA = National Fire Protection Association. NIOSH = National Institute of Occupational Safety and Health. NJTSR = New Jersey Trade Secret Registry. NTP = National Toxicology Program. OSHA = Occupational Safety and Health Administration. NA = Not available or Not Applicable. SARA = Superfund Amendments and Reauthorization Act. TLV = Threshold Limit Value. TSCA = Toxic Substance Control Act. WHMIS = Workplace Hazardous Materials Information System.

This is the end of MSDS # SM-100

ETi6242-1B Powder

SAFETY DATA SHEET

Section 1. Identification

Product identifier used on the label: ETi6242-1B Powder
Other means of identification: Ti-6Al-2Sn-4Zr-2Mo-0.08Si-1B
Product type: Solid
Recommended use and restrictions
Identified uses: Not available.
Supplier's details :

Puris, LLC
78 Northpointe Dr.
Bruceton Mills, WV 26525
Phone: 304-777-4270
Fax: 304-842-1972

Emergency telephone number (with hours of operation): 304-777-4270 M-F 8AM-5PM

Section 2. Hazards identification

Classification of the substance or mixture: Not classified as flammable solid to CFR Title 49 Vol. 2 Appendix E
Ingredients of unknown toxicity: Not applicable
Ingredients of unknown ecotoxicity: Not applicable

GHS label elements
Hazard pictograms :
Signal word : Danger
Hazard statements : Flammable solid.
Precautionary statements
General : Read label before use. Keep out of reach of children. If medical advice is needed, have product container or label at hand.

Prevention : Wear protective gloves. Wear eye or face protection. Keep away from heat, sparks, open flames and hot surfaces. - No smoking.
Response : Not applicable.
Storage : Not applicable.
Disposal : Not applicable.
Other hazards which do not result in classification: Not available.

Section 3. Composition/information on ingredients

Substance/mixture: Mixture
Other means of identification : Enhanced Ti-6Al-2Sn-4Zr-2Mo-0.08Si, ETi-6Al-2Sn-4Zr-2Mo-0.08Si, Ti-Ti-6Al-2Sn-4Zr-2Mo-0.08Si-1B
CAS number/other identifiers
CAS number : Not applicable
EC number : Mixture.
Product code : Not available.

Nominal Composition

ETi6242-1B Powder

Element	Percentage (wt%)	CAS Number
Titanium	84.92	7440-32-6
Aluminum	6	7429-90-5
Tin	2	7440-31-5
Zirconium	4	7440-67-7
Molybdenum	2	7439-98-7
Silicon	0.08	7440-21-3
Boron	1	7440-48-2

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified as hazardous to health or the environment and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Eye contact

Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 20 minutes. Get medical attention if irritation occurs.

Inhalation

Remove victim to fresh air and keep at rest in a position comfortable for breathing. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention if adverse health effects persist or are severe. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact

Flush contaminated skin with plenty of water. Remove contaminated clothing and shoes. Get medical attention if symptoms occur. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion

Wash out mouth with water. Remove dentures if any. Remove victim to fresh air and keep at rest in a position comfortable for breathing. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention if adverse health effects persist or are severe. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects
Inhalation : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Eye contact : No known significant effects or critical hazards.
Over-exposure signs/symptoms
Skin contact No specific data.
Ingestion No specific data
Inhalation No specific data
Eye contact : No specific data.

Section 4. First aid measures

Indication of immediate medical attention and special treatment needed, if necessary
Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.
Specific treatments : No specific treatment.
Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. Itmay be dangerous to the person providing aid to give mouth-to-mouth resuscitation.
See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media
Suitable extinguishing media: Use a Type D fire extinguisher for metal fires.
Unsuitable extinguishing media: Do not use water or foam. Do not use CO_2.
Specific hazards arising from the chemical: Flammable solid.
Hazardous thermal decomposition products: Decomposition products may include the following materials: metal oxide/oxides
Special protective actions for fire-fighters: Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk.
Special protective equipment for fire-fighters: Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
For non-emergency personnel:
No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders
If specialised clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions: Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill: Move containers from spill area. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor.

Large spill : Move containers from spill area. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Vacuum or sweep up material and place in a designated, labeled waste container. Cleaning tools must be a soft natural fiber brush or squeegee with non-sparking, conductive scoops used to pick up the collected material. Synthetic fiber bristle brushes and plastic or other nonconductive scoops must not be used, since they tend to accumulate strong static charges. Standard commercial industrial vacuum cleaners must not be used during cleaning. Vacuum cleaning systems, designed and certified for use with Group E combustible dusts may be used, with limitations (see NFPA 484). Dispose via a licensed waste disposal contractor. Note: see section 1 for emergency contact information and section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Put on appropriate personal protective equipment (see Section 8). Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. Do not ingest. Avoid contact with eyes, skin and clothing. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use only non-sparking tools.
Empty containers retain product residue and can be hazardous. Do not reuse container.

Conditions for safe storage, including any incompatibilities

Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well ventilated area, away from incompatible materials (see section 10) and food and drink. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination.

Section 8. Exposure controls/personal protection

Control parameters - Occupational exposure limits

Ingredient name	Exposure Limits
Aluminum	**NIOSH REL (United States)**
	TWA: 5 mg/m³ 10 hour(s). Form: Respirable fraction
	TWA: 10 mg/m³ 10 hour(s). Form: Total
	OSHA PEL (United States)
	TWA: 5 mg/m³, (as Al) 8 hour(s). Form: Respirable fraction
	TWA: 15 mg/m³, (as Al) 8 hour(s). Form: Total dust
	ACGIH TLV (United States)
	TWA: 1 mg/m³ 8 hour(s). Form: Respirable fraction
Tin	**NIOSH REL (United States)**
	TWA: 2 mg/m³
	OSHA PEL (United States)
	TWA: 2mg/m³
	ACGIH TLV (United States)
	TLV: 2 mg/m³
Zirconium	**NIOSH REL (United States)**
	TWA: 5 mg/m³
	OSHA PEL (United States)
	TWA: 5 mg/m³
	ACGIH TLV (United States)
	TLV: 5 mg/m³
Molybdenum	**NIOSH REL (United States)**
	not established
	OSHA PEL (United States)
	TWA: 5 mg/m³
	ACGIH TLV (United States)
	TWA: 5 mg/m³
Silicon	**NIOSH REL (United States)**
	TWA: 10 mg/m³
	OSHA PEL (United States)
	TWA: 15 mg/m³

	ACGIH TLV (United States)
	not available

Boron	**NIOSH REL (United States)**
	TWA: 10 mg/m³
	OSHA PEL (United States)
	TWA: 15 mg/m³
	ACGIH TLV TWA (United States)
	TLV: 10 mg/m³

Recommended monitoring procedures
If this product contains ingredients with exposure limits, personal, workplace atmosphere or biological monitoring may be required to determine the effectiveness of the ventilation or other control measures and/or the necessity to use respiratory protective equipment.

Appropriate engineering controls
Use only with adequate ventilation. If user operations generate dust, fumes, gas, vapor or mist, use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls: Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures
Hygiene measures
Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.
Eye/face protection Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts.

Skin protection
Hand protection
Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary.
Body protection Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.
Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection
Use a properly fitted, air-purifying or supplied air respirator complying with an approved standard if a risk assessment indicates this is necessary. Respirator selection must be based on known or anticipated exposure levels, the hazards of the product and the safe working limits of the selected respirator.

Section 9. Physical and chemical properties

Appearance
Physical state Solid. [Gray spherical powder]
Color Gray.
Odor Odorless.
Odor threshold Not available.
pH: Not available.
Melting point/freezing point: 1600°C (2912°F)
Boiling point/boiling range : 3200°C (5792°F)
Flash point Not available.
Evaporation rate Not available.
Flammability (solid, gas) : Not available.
Lower and upper explosive (flammable) limits: Not available.
Vapor pressure: Not available.
Relative density: 4.5
Vapor density: Not available.
Solubility: Insoluble in the following materials: cold water and hot water.
Partition coefficient: n-octanol/water Not available.
Auto-ignition temperature Not available.
Viscosity Not available.
SADT : Not available.
Decomposition temperature : Not available.

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.
Chemical stability The product is stable.
Possibility of hazardous reactions: Under normal conditions of storage and use, hazardous reactions will not occur.
Conditions to avoid Heat, flames, ignition sources and incompatibles.
Incompatible materials : Mineral acids, Molten alkali salt, Liquid oxygen, Oxides of Cu, Fe, Bi and some others. Carbon dioxide (CO_2).
Hazardous decomposition products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects
Acute toxicity
There is no data available.
Irritation/Corrosion

ETi6242-1B Powder

Skin : Not available.
Eyes : Not available.
Respiratory : Not available.
SensitizationThere is no data available.

Carcinogenicity There is no data available.

	ACGIH	IARC	EPA	NIOSH	NTP	OSHA
Aluminum	A4	-	-	-	-	-
Tin	A4	-	-	-	-	-
Molybdenum	A4	-	-	-	-	-
Zirconium	A4	-	-	-	-	-
Silicon	A4	-	-	-	-	-
Boron	A4	-	-	-	-	-

Mutagenicity There is no data available.
Teratogenicity There is no data available.
Reproductive toxicity There is no data available.
Specific target organ toxicity (single exposure) There is no data available
Specific target organ toxicity (repeated exposure): There is no data available.
Aspiration hazard There is no data available.
Information on the likely routes of exposure: Routes of entry anticipated: Oral, Dermal, Inhalation.

Potential acute health effects
Eye contact : No known significant effects or critical hazards.
Inhalation : No known significant effects or critical hazards.
Skin contact : No known significant effects or critical hazards.
Ingestion : No known significant effects or critical hazards.

Symptoms related to the physical, chemical and toxicological characteristics
Eye contact : No specific data.
Inhalation No specific data.
Skin contact: No specific data.
Ingestion: No specific data.

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure
Potential immediate effects: Not available.
Potential delayed effects : Not available.

Long term exposure
Potential immediate effects: Not available.
Potential delayed effects: Not available.

Potential chronic health effects
General : No known significant effects or critical hazards.
Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.
Teratogenicity : No known significant effects or critical hazards.
Developmental effects : No known significant effects or critical hazards.
Fertility effects : No known significant effects or critical hazards.
There is no data available.
Numerical measures of toxicity
Acute toxicity estimates: There is no data available.

Section 12. Ecological information

Toxicity
There is no data available.
Persistence and degradability
There is no data available.
Bioaccumulative potential There is no data available.
Mobility in soil
Soil/water partition coefficient (K_{OC}): Not available.
Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods
The generation of waste should be avoided or minimized wherever possible. Significant quantities of waste product residues should not be disposed of via the foul sewer but processed in a suitable effluent treatment plant. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Disposal of this product, solutions and any by-products should comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling empty containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT	IMDG	IATA
UN number	NA	UN2546	UN2546
UN proper shipping name	NA	Titanium powder, dry	Titanium powder, dry
Transport Hazard Class(es)	NA	4.2	4.2
Packing Group	NA	II	II
Environmental Hazards	NO	NO	NO
Special Precautions for User	NA	NA	NA
Additional Information	-	-	-

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: Not available

Section 15. Regulatory information

Safety, health and environmental regulations specific for the product:
No known specific national and/or regional regulations applicable to this product (including its ingredients).

U.S. Federal regulations

TSCA 8(a) IUR Exempt/Partial exemption: Not determined
United States inventory (TSCA 8b): All components are listed or exempted.
SARA 302/304/311/312 extremely hazardous substances: No products were found.
SARA 302/304 emergency planning and notification: No products were found.
SARA 302/304/311/312 hazardous chemicals: Titanium; Aluminum;
SARA 311/312 MSDS distribution - chemical inventory - hazard identification: Titanium: Fire hazard, Delayed (chronic) health hazard; Aluminum: Fire hazard, reactive
Clean Air Act Section 112(b) Hazardous Air Pollutants (HAPs): Not listed
Clean Air Act Section 602 Class I Substances : Not listed
Clean Air Act Section 602 Class II Substances : Not listed
DEA List I Chemicals (Precursor Chemicals) : Not listed
DEA List II Chemicals (Essential Chemicals) : Not listed

SARA 313

	Element	CAS Number	Composition (wt%)
Form R - Reporting Requirements	Titanium	7440-32-6	84.92
	Aluminum	7429-90-5	6
	Tin	7440-31-5	2
	Zirconium	7440-67-7	4
	Molybdenum	7439-98-7	2
	Silicon	7440-21-3	0.08
	Boron	7440-48-2	1
Supplier Notification	Titanium	7440-32-6	84.92
	Aluminum	7429-90-5	6
	Tin	7440-31-5	2
	Zirconium	7440-67-7	4
	Molybdenum	7439-98-7	2
	Silicon	7440-21-3	0.08
	Boron	7440-48-2	1

SARA 313 notifications must not be detached from the MSDS and any copying and redistribution of the MSDS shall include copying and redistribution of the notice attached to copies of the MSDS subsequently redistributed.

State regulations

Massachusetts The following components are listed: Aluminum
New York : None of the components are listed.
New Jersey : The following components are listed: Titanium; Aluminum

ETi6242-1B Powder

Pennsylvania : The following components are listed: Aluminum;
California Prop. 65: No products were found.

Section 16. Other information

History
Date of issue mm/dd/yyyy: 07/24/2014
Version: 1
Prepared by : Puris, LLC.
Key to abbreviations :
ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL 73/78 = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
UN = United Nations

Notice to reader
To the best of our knowledge, the information contained herein is accurate. However, neither the above-named supplier, nor any of its subsidiaries, assumes any liability whatsoever for the accuracy or completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist.

ATTACHMENT E

Supporting Calculations

Puris PAM Unit

Emission Unit Characteristics

Unit Type:	Plasma Arc Cold-Hearth Melting Furnace
Unit ID:	PAM
Manufacturer:	Retech Systems LLC
Model No.	

Physical Parameters:

Temperature	=	1660	°C
	=	1933.15	°K
Ar MW	=	39.948	
He MW	=	4.002	
Ar flow	=	2.82	kg/min
He flow	=	0.065	kg/min
Ar flow	=	0.071	mol/min
He flow	=	0.016	mol/min
Total flow	=	0.087	mol/min
Furnace pressure	=	15	psia
	=	1.02	atm

PAM Cycle time

Melt & Pour	=	3.0	hrs
Cool	=	3.0	hrs
Replace molds	=	1.0	hrs
Total Cycle	=	7.0	hrs

Emissions only occur during the melt phase

Molten material solidifies almost immediately after torch off

Emitting hours = 8,760 hr/yr x (3.0 / 7.0)

= 3,754 hr/yr

Emissions Determinations

Particulate Matter

Uncontrolled emissions

Product 1	=	**0.53**	**lb/hr**			
Product 1	=	0.53	x	3,754	/	2000
	=	**0.99**	**TPY**			

Product 2	=	**0.02**	**lb/hr**			
Product 2	=	0.02	x	3,754	/	2000
	=	**0.04**	**TPY**			

Product 3	=	**0.11**	**lb/hr**			
Product 3	=	0.11	x	3,754	/	2000
	=	**0.20**	**TPY**			

Product 3	=	**0.11**	**lb/hr**		
Product 3	=	0.11	x	3,754 /	2000
	=	**0.20**	**TPY**		

Mass Fraction

MW		Product 1 Gamma	Product 2 NiTi	Product 3 Eti-6242	Product 4 Ti64
47.86	Ti	57.7%	60.0%	85.0%	90.0%
26.98	Al	33.38%		6.0%	6.0%
51.99	Cr	2.4%			
92.90	Nb	4.5%			
10.81	B	0.0%		1.0%	
183.84	W	2.0%			
95.95	Mo			2.0%	
50.94	V				4.0%
91.22	Zr			4.0%	
58.69	Ni		40.0%		
118.71	Sn			2.0%	
		1	1	1	1

Moles

	Product 1	Product 2	Product 3	Product 4
Ti	0.0121	0.0125	0.0178	0.0188
Al	0.0124	0	0.0022	0.0022
Cr	0.0005	0	0	0
Nb	0.0005	0	0	0
B	0	0	0.0009	0
W	0.0001	0	0	0
Mo	0	0	0.0002	0
V	0	0	0	0.0008
Zr	0	0	0.0004	0
Ni	0	0.0068	0	0
Sn	0	0	0.0002	0
	0.0255	0.0194	0.0217	0.0218

Mole Fraction (liquid phase)

	Product 1	Product 2	Product 3	Product 4
Ti	0.473	0.648	0.818	0.862
Al	0.485	0	0.102	0.102
Cr	0.018	0	0	0
Nb	0.019	0	0	0
B	0.001	0	0.043	0
W	0.004	0	0	0
Mo	0	0	0.010	0
V	0	0	0	0.036
Zr	0	0	0.020	0
Ni	0	0.352	0	0
Sn	0	0	0.008	0

	Coefficients			
	A	B	C	D
Ti	6.358	-22747	0	0
Al	5.911	-16211	0	0
Cr	6.02371	16065	-83.86	
Nb	6.929	-25011	0	0
B				
W				
Mo				
V	6.929	-25011	0	0
Zr	6.806	-30295	0	0
Ni	6.666	-20765	0	0
Sn	5.2262	-15332	0	0

Vapor pressure (atm)

	Product 1	Product 2	Product 3	Product 4
Ti	3.90E-06	3.90E-06	3.90E-06	3.90E-06
Al	3.35E-03	3.35E-03	3.35E-03	3.35E-03
Cr	2.17E-03	2.17E-03	2.17E-03	2.17E-03
Nb	9.80E-07	9.80E-07	9.80E-07	9.80E-07
B	2.69E-06	2.69E-06	2.69E-06	2.69E-06
W				
Mo	7.70E-11	7.70E-11	7.70E-11	7.70E-11
V	9.80E-07	9.80E-07	9.80E-07	9.80E-07
Zr	1.36E-09	1.36E-09	1.36E-09	1.36E-09
Ni	8.40E-05	8.40E-05	8.40E-05	8.40E-05
Sn	1.97E-03	1.97E-03	1.97E-03	1.97E-03

Mole Fraction (vapor phase)

	Product 1	Product 2	Product 3	Product 4
Ti	1.84E-06	2.53E-06	3.19E-06	3.36E-06
Al	1.63E-03	0	0	3.42E-04
Cr	3.93E-05	0	0	0
Nb	1.86E-08	0	0	0
B	1.95E-09	0	0	0.00E+00
W	0	0	0	0
Mo	0	0	0	0
V	0	0	0	3.53E-08
Zr	0	0	2.75E-11	0
Ni	0	2.96E-05	0	0
Sn	0	0	1.53E-05	0

	Mass rate (vapor phase, lb/hr)			
	Product 1	Product 2	Product 3	Product 4
Ti	1.01E-03	1.39E-03	1.75E-03	1.85E-03
Al	5.04E-01	0	0	1.06E-01
Cr	2.35E-02	0	0	0
Nb	1.99E-05	0	0	0
B	2.42E-07	0	0	0
W	0	0	0	0
Mo	0	0	0	0
V	0	0	0	2.06E-05
Zr	0	0	2.88E-08	0
Ni	0	2.00E-02	0	0
Sn	0	0	2.09E-02	0
	5.28E-01	2.13E-02	1.08E-01	1.08E-01

Assumption: all vaporized metals are swept
by Ar/He venting from furnace.
Reality is most condense as particulate
on furnace walls.

Assumption: total vapor pressure equal to sum
of pure components

References for Antoine Equation constants

1 Cr http://webbook.nist.gov/cgi/cbook.cgi?Name=chromium&Units=SI&cTP=on
2 Mo https://www.nist.gov/sites/default/files/documents/srd/jpcrd313.pdf
3 B http://www.physics.nyu.edu/kentlab/How_to/ChemicalInfo/VaporPressure/mo
4 All others Alcock, CB. Canadian Metallurgical Quarterly, 23, 309, 1984.

Log P = A + B/T + ClogT + D/T^3
Log P = A + B/T + ClogT + D/T^3
$\log_{10}(P) = A - (B / (T + C))$

Vapor Pressure: 4.6 x 10-4 to 8.5 x 10-3 mm @2200 K
log P (atm) = 45385/T (K) + 7.871

Log P = A + B/T + ClogT + D/T^3
Log P = A + B/T + ClogT + D/T^3

PAM PTE SUMMARY

Size, µm	<2.5	<6.0	<10.0	Total
Cumulative Percent at Less Than Stated Size	82	89	92	100
Cumulative Uncontrolled Particulate Generation at Less Than Stated Size (lb/hr)	0.35	0.43	0.49	0.53
Cumulative Uncontrolled Particulate Generation at Less Than Stated Size (ton/yr)	0.81	0.88	0.91	0.99

repressure.pdf

Boron vapor pressure @ 1933.15 °K 2.69E-06 atm

Pa

1	10	100	1000	10000	100000
2075	2289	2549	2868	3272	3799

B	Boron	T (°K)	Pressure	Log P		
		1900	3.92E-11	-10.4067		
		2000	3.01E-10	-9.52143	Δ T	Δlog P/Δ T
		1933.15	7.70E-11	-10.1132	33.15	0.008853

Puris EIGA Unit

Emission Unit Characteristics

Unit Type:	Electrode Induction Gas Atomization
Unit ID:	EIGA
Manufacturer:	ALD Vacuum Technologies
Model No.	

Physical Parameters:

Electrode feed speed	=	28	mm/min
Electrode feed speed	=	1.1	in/min
Atomizable Electrode length	=	39	in
Electrode diameter	=	2.75	in
Atomizable Electrode volume	=	231.6	in^3
Titanium density	=	0.164	lb/in^3
Atomizable Electrode mass	=	38.0	lb
Time to atomize one electrode	=	35.4	min
Turnaround time between electrodes	=	9.4	min
Electrode cycle time	=	44.8	min
Effective atomization rate	=	50.9	lb/hr
Clean tower	=	4	hrs
every		7	days
Process down time	=	4 /	(7 x 24)
	=	2.4%	
Operating hours/yr	=	8,760 x	(1 - 0.024)
	=	8,551	hrs/yr
Cyclone recovery	=	96.43%	
HEPA filter collection efficiency	=	99.95% @	0.3 μ

Production rate:

	=	50.9	lb/hr

Post Cyclone (not APC, product recovery)

PM	=	51 x	(1 - 96.4%)
	=	1.8	lb/hr

Emissions Determinations

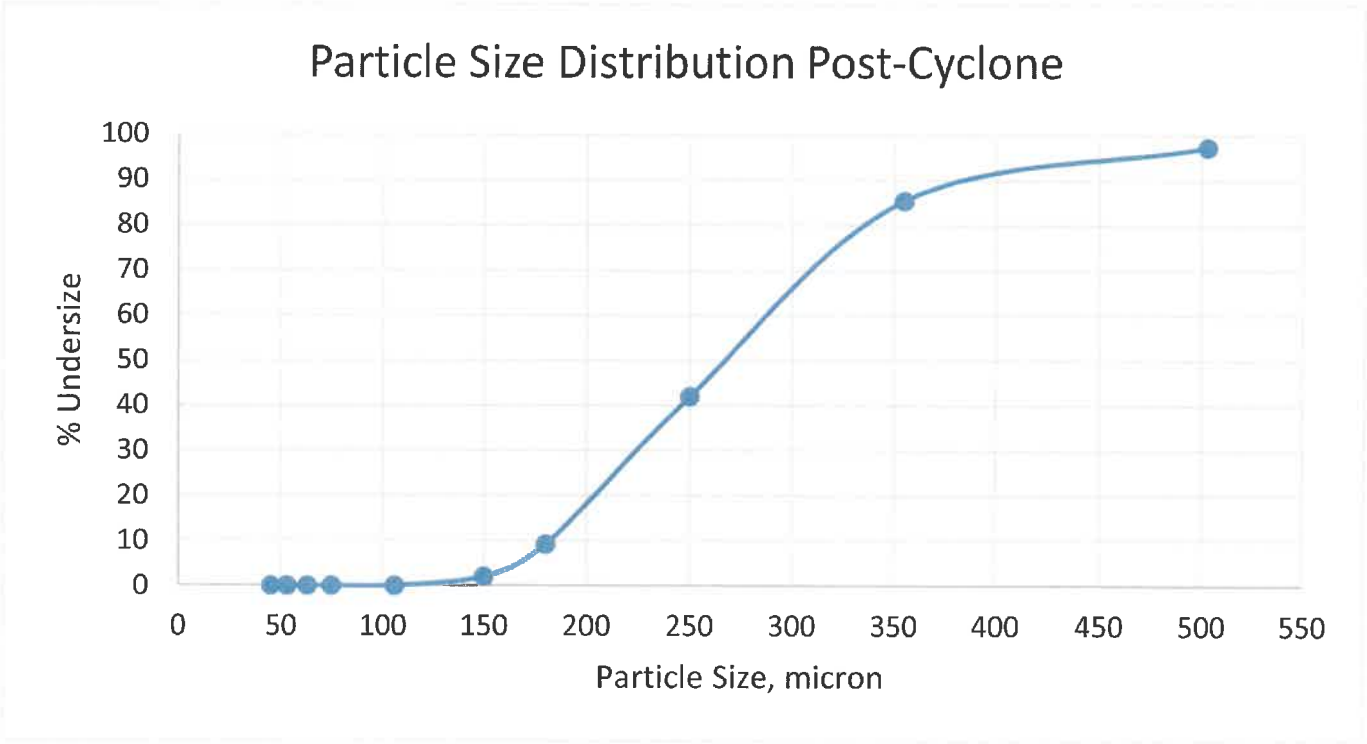
Particulate Matter			
Uncontrolled emissions	=	1.8	lb/hr
	=	1.8 x	8,551 / 2000
	=	7.77	TPY

Post HEPA Filter

Potential hourly emissions	=	1.8 x	(1 - 99.95%)
	=	**0.001**	**lb/hr**
Potential annual emissions	=	0.001 x	8,551 / 2000
	=	**0.00**	**TPY**

EIGA PTE SUMMARY

Size Range (micron)	<2.5	2.5-6	6-10	10-30	>30
Collection Eff (%) (HEPA filter @ 0.3 μm)	99.95	99.95	99.95	99.95	99.95
Generic distribution (%), cum. % < given size	0	0	0	0	100
Mass in size range before control (ton/yr)	0	0	0	0	7.8
Mass in size range before control (lb/hr)	0	0	0	0	1.8
Mass in size range after control (ton/yr)	0	0	0	0	0.00
Mass in size range after control (lb/hr)	0	0	0	0	0.001
Cumulative Mass before Control (ton/yr)	0	0	0	0	7.77
Cumulative Mass before Control (lb/hr)	**0**	**0**	**0**	0	1.82
Cumulative Mass after Control (ton/yr)	0	0	0	0	0.00
Cumulative Mass after control (lb/hr)	0	0	0	0	0.001


Particle Size Distribution Post-Cyclone
% Undersize
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
400
450
500
550
Particle Size, micron